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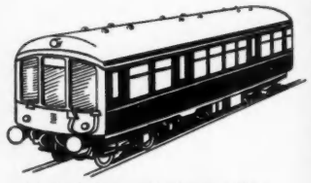
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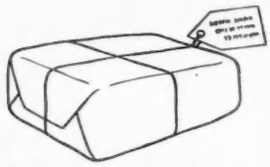
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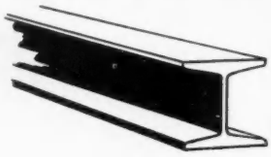
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Those Born After 1939

Few people outside electrical engineering, apart from careers masters, will have heard of a booklet which the Institution of Electrical Engineers published this week. Its title is *The Education and Training of Student Apprentices in Electrical Engineering*. For the price of 2*s*., the student apprentice, his father, his schoolmaster or the engineer who will guide his early years in the profession, is presented with wise advice and information on the planning of a career in this branch of engineering. It tells the employer what he should do if he wants well-trained men in the future.

The importance of this booklet can hardly be exaggerated. There are three fundamental reasons for making such a sweeping claim: (1) because it is concerned with one of the most rapidly advancing branches of engineering, on which so much of the national interest depends, (2) because it is designed to assist the next generation of engineers, many of whom, having been born after 1939, will still be engaged in their profession well after the turn of the century, and (3) because it combines the practical, down-to-earth outlook of engineers with the breadth of vision which the subject demands. It is not often that committees produce a lively and stimulating document, but the I.E.E. committee which prepared this booklet, under the chairmanship of Sir Willis Jackson, have achieved just that.

A short quotation will show these qualities: " The student must also realise that although the completion of his apprenticeship and the attainment of his basic educational qualifications are important milestones in his progress, they are not the zenith—his studies must extend well beyond these formal attainments. Particularly in his years as a practising engineer, he will need to study one or more specialised subjects in great depth; at the same time he must widen his horizon by reading in other branches of science and technology and in social, economic and related fields, so that he may see his specialised contribution in its true setting. Throughout his career he will have to adapt himself to new situations as he is brought into contact with the changing problems of technology and administration. Indeed his training will have failed in an essential purpose if it does not create an urge to initiate such changes."

Because it is more than likely that many of the engineers who are being trained to-day will eventually undertake responsibilities that are far removed from the purely technical side of engineering—some may be administrators in other industries where their training in scientific and empirical methods will be extremely valuable—they will be grateful to the I.E.E. for having encouraged a foundation of wider interests, on which their inevitable specialisations will flourish. If they acquire the urge to initiate change, then the work of this I.E.E. committee will pay incalculable dividends.

The graduate route for becoming an electrical engineer was the subject of an earlier report published by the Institution—the normal procedure is to pursue a full-time course of study at a university or college, followed by a two-year period in industry as a graduate apprentice. The student apprentice, on the other hand, follows a closely integrated course, generally lasting for five years, of theoretical study at a college, coupled with industrial training in manufacture or with an operating concern. This is a more practical approach than the graduate scheme; the choice should be carefully made in relation to the individual boy's interests and aptitudes. But if the student apprenticeship is elected it is important to ensure that the practical training arrangements are up to the standard required by the Institution. A student apprentice is normally recruited at about 18 years of age after success in the examination for the General Certificate of Education at Advanced Level. The special route for craft or technician apprentices whose real ability and academic potential for professional training take some time to develop will still be left open.

Of the two types of sandwich course for student apprentices—industry-based and college-based—the Institution imply a preference for the industry-based course because there is a better chance of the practical training being properly arranged and co-ordinated. Large engineering firms have for years given admirable practical training, but there is now an urgent need for small and medium firms to co-operate in establishing group training schemes. There are several examples of such group training schemes already working in this country. It is probably the best insurance that a small or medium firm can invest in if they wish to recruit a few high-quality engineers in the future. There is therefore a fourth reason for saying that the importance of this booklet cannot be exaggerated: an engineer can greatly extend his service to the community if he voluntarily decides to help and guide young engineers in their early years. Indirectly, though he may have been born before the turn of this century, he will contribute to the world of the 21st century.

Cover picture: *The Spiteful, designed to an Air Ministry specification as a replacement for the Spitfire, was the last piston-engine fighter bred in the Supermarine stable. It had a laminar flow wing of straight configuration, in contrast to the elliptical planform of the Spitfire. The prototype, powered by a Griffon 61 engine, achieved a speed of 494 m.p.h. in level flight—believed to be the highest ever by a piston-engine aircraft.*

* * *

Plain Words

A high wind one night and a row of houses lose their flat roofs. A public inquiry—and the architect and the building contractor are censured. Few engineers, reading the report of the committee of inquiry which was published last week, would not have thought but for the grace of God, there go I. Who among us has never signed his name to something about which he had only the vaguest notion? Do all company directors know all they should about company law? How many committee chairmen have studied the rules for conducting meetings?

The relentless demands made on men in authority, the speed with which decisions have sometimes to be given, the continual requests to cut costs—saving a penny here and another there—all serve to increase the risk of trouble in building and civil engineering jobs. Engineers run this risk more than most professional men. The difficulties are partly in design and partly in the communication of information and orders. In neither is the responsibility always clear-cut. It is seldom possible for the designer to take each component and examine it in isolation, and it is not easy to foresee all the possible conditions under which the component will be expected to survive. Even such a simple, traditional component as a rafter which has been designed to support the roof covering, a snow load and a point load of unspecified character—maybe a hefty youth scrambling over the roof to replace a tile—may still be called upon to carry a block and tackle for moving a machine. And if this example seems too ordinary, I can think of plenty of a more involved kind. I shudder now to think of calculations that were very shaky indeed from over simplification. Nothing that I perpetrated ever went dangerously adrift (as far as I know), but certainly on a few occasions it was a relief to see that an idea *did* work.

But the nagging thought that something might go wrong keeps cropping up. Whether it defeats a man or not depends on his temperament. Most of us get by, but one man I knew of got so worked up over his designs that in the end he had to come off the drawing board. It was a loss, because he was a good man at calculations and had plenty of sound experience. His fault was only a lack of self-confidence. The more serious fault is a failure to keep up to date in technical knowledge. There is no room for the half-awake in engineering to-day.

CAPRICORN

Weekly Survey

Top Defence People

The White Paper published last week on the future of the central organisation of defence is mainly a political document. It sets out the composition and operation of the Defence Committee of the Cabinet and a Defence Board which is to help the Minister of Defence to formulate defence policy and, thirdly, notes certain adjustments in staff organisation for the Chiefs of Staff. The Government's original intention to set up a Defence Board and to translate the chairman of the Chiefs of Staff Committee into Chief of the Defence Staff has been retained but the constitutional position of the Service Ministers has been preserved. These Ministers are on both the Defence Committee and the Defence Board and in this way they will have access to the Cabinet on all matters relating to their departments. There is no question of their views being stifled at Defence Board level.

Another important change is that, though the Chiefs of Staff will continue to give their military advice collectively to the Minister of Defence, the Chief of the Defence Staff—a post created under the new arrangement—will not only report differences between the Chiefs of Staff but will also give his own advice. This is intended to prevent advice being the lowest common denominator among the three services, but it also clearly increases the authority of the Service chief who was formerly chairman of the Chiefs of Staff Committee and is now chief of the Defence Staff.

The new arrangement thus preserves flexibility at the expense of unanimity. So far as technical advice is concerned this is a definite advantage. The Defence Board is not conspicuous for the weight of technical opinion it can muster. It consists of five Ministers, including the Minister of Supply, the chief of the Defence Staff, the chiefs of staffs of the three services, the Permanent Secretary and the Chief Scientist of the Ministry of Defence. In as much as the Minister of Supply and his Chief Scientist are members of the board, technical matters will get as good a hearing as they do now. Under the original proposals for reorganising, the top defence committees technical advice might have been smothered at a lower level. It cannot be said, however, that the technical point of view has gained significantly in the reshuffle.

Aircraft Credit

Speaking in the House of Lords last week for the Government in a debate on the future of the aircraft industry, Lord Mancroft said that in the immediate future the Government envisaged a partnership between State and industry. The one would finance basic research and the other aircraft development and production. The Government would be prepared to consider individual cases on their merits for developing new techniques out of public funds.

This was as much as a Government spokesman would say in response to a debate in which the chairmen of several of the companies concerned took part. Viscount Knollys said that his Vickers group had already provided in the last two years more than £4 million on the Vanguard and this was not the end of the development charges. Lord Kindersley, chairman of Rolls-Royce said that there were limits to the number of types of aero-engines which the industry could afford to develop at its own cost at £15 million to £20 million a time.

Lord Mancroft paid a tribute to the export performance of the industry, but there were no hints about improved credit facilities forthcoming. This is one point at which progress might be made. The American challenge is still the biggest one in the world aircraft market and the United States is not a party to the Berne credit agreements. American companies normally give seven years credit and the Lockheed Electra turbo-prop is thought to have been offered to some airlines for a trial period of two years. Apart from short-term assistance, one of the basic problems still to be solved in this country is the development of a supersonic airliner. The industry is co-operating with the Royal Aircraft Establishment at Farnborough but beyond the technical problems lies a decision as to whether and under what conditions such an airliner would be economic. On the Government's ability to take an imaginative view (which means a combination of shrewdness and boldness) lies the hope for the sound long-term development of the aircraft industry in this country.

The Iraq Revolt

Last week-end an agreement was signed at Geneva between the United Arab Republic and the Suez Canal Company paying out £23 million in compensation for the expropriation of the Suez Canal. In less than a week the revolt in Iraq had opened up a new critical situation in the Middle East. Although this country's biggest asset in Iraq is the Iraq Petroleum Company (the United Kingdom share of that company's assets is about £40 million) the Iraq situation does not immediately involve a crisis in oil supplies. There is plenty of oil in stock throughout the world and 350 tankers amounting to 5·6 million deadweight tons seeking cargo. It will be a different story if political trouble spreads to the sheikhdoms of the Persian Gulf.

This country's export trade to Iraq is worth about £30 million a year, a not dissimilar figure to the annual level of exports to Egypt before the Suez Canal crisis. Of this total a high proportion is of engineering goods. On the civil engineering side this country is fairly heavily committed to the development of Iraqi resources. The Iraq development board receives 70 per cent of the total oil income of that country as its revenue, which amounts to over £80 million a year. The Six-Year Plan ends in 1960 and by then about £500 million will have been spent on flood control, irrigation, roads and public buildings. Of this the United Kingdom has been receiving about £10 million a year. In the past the United Kingdom interest has been mainly in irrigation schemes but it has been spreading recently into a wider range of projects, particularly a trunk road system involving a number of major bridges.

Many of the civil engineering schemes are organised by international consortia and to that extent British contractors may be protected from unfavourable discrimination by a nationalistic government at Baghdad. It may be otherwise with British exports which have had a valuable market in that country for many years.

Scientific Film Review

The rapid growth in the membership of the Scientific Film Association—it has increased by over 45 per cent, to 404, since 1956—suggests that a very live interest exists in industry and commerce in the development of the film as a tool of management. In their annual review of the year ended 31 March, the Association point out that they are in the unusual position of representing the interests of the sponsors, makers and users of scientific films. Largely because of this, and because of the accelerating rate of recruitment of corporate members, they claim they are making "a very positive contribution towards the wider and more dis-

criminating use of scientific, industrial, technical and medical films."

The Association's terms of reference are "to study, discuss, publicise, and advocate the use of scientific and industrial films, and to promote a wider understanding of science and of the scientific outlook." To discharge this they provide information on films, organise a wide variety of activities, execute special commissions for members and clients and co-operate with interested individuals and organisations. One of the means of providing information is through the publication of *Scientific Film Review*, which appeared six times during the year under review and provided information on over a thousand films. Nearly half of these were fully reviewed, and technical and distribution details provided for the remainder. The publication of catalogues and articles is another means of disseminating information used by the Association. Three catalogues were published during the year, with detailed reviews or appraisals of 44 films on special medical problems, 131 on psychology and psychiatry, and 100 on education. Technical data and a synopsis of content of 93 films on automation were supplemented by an analytical article which gave much detailed statistical information.

A great deal of help is given to the Association by many voluntary workers. This has made possible—in film appraisal particularly—the collection and classification of a considerable amount of information. Viewing facilities have been provided by industry, including B.I.S.F., G.E.C. Research Laboratories, John Laing and Son, and Mullard in the metal and engineering industries. The annual report of SFA gives examples of their work and is a useful guide to those firms interested in making use of scientific films or wishing to assess their potential contribution to managerial or educational problems.

Grey Grass of Kentucky?

A study has been made during 1956 and 1957 of the causes of air pollution in Louisville, Kentucky, United States. The investigation was financed by local industry and used certain services available from the Federal Government. Louisville itself is a town about the size of Leeds and is on the Ohio River 600 miles south west from Pittsburgh.

The town has a fairly large industrial area producing chemicals, synthetic rubber, aluminium sheet, cement and carbide. This added up over several decades of rising prosperity to a considerable smog problem, though Louisville's reputation never achieved the international notoriety of certain areas of Pennsylvania further up the Ohio River. Nevertheless a systematic survey discovered that about 440 tons of pollutants per day were discharged to the air over the town. How much fell upon the city depended on weather, season, time of day and so on. There were three main sources of pollution. Domestic heating, including cooking, accounted for 9 per cent of it. Automobiles, trucks, trains and buses accounted for 6 per cent and, by far the largest, the industrial zone contributed 85 per cent. In consequence, a major part of the study was devoted to the industrial pollutants. The biggest single pollutant by far put out by industry was sulphur dioxide, followed by certain acids and nitrogen oxides. Analysis of the results showed that a very high proportion of the dust sent up by industry comes from power stations using large quantities of pulverised coal. Indeed, the largest source of solid pollution is industrial coal combustion; the next largest source is coal burning in homes. Combustion of fuels for power stations is already a major source of pollution by gases.

The report, entitled *The Air over Louisville*, emphasises that the investigation concerned only the problem of Louisville and that pollution surveys would show different results for different areas. So far as that town is concerned the authors recommend strict adherence to a standard prohibiting the emission of solids above a certain concentration, a maximum content of sulphur in coal used (which would surely be difficult to enforce on economic grounds), reduction in the emission of hydro-carbon vapours from the evaporation of fuels. The survey has thus produced broad results which are in line with the ideas which lie behind the smokeless zone legislation in this country. To-day the basic problem is the enforcement of reasonable standards which, while protecting the public, are not grossly unfair to industry.

Data Processing

The scope of the International Conference on Information Processing is indicated by the six main topics: methods of digital computing; logical design; common symbolic language for digital computers; automatic translation of languages; collection, storage, and retrieval of information; pattern recognition and machine learning. (The fifth topic will possibly be of personal interest to the delegates, who will be faced with an intensive programme.) About 66 papers are likely to be discussed in the course of 11 sessions of three hours each. The conference will be held from 15 to 20 June, 1959, in Paris.

The United Nations Educational, Scientific and Cultural Organisation is organising the conference, with the help of consultants from various countries. National groups are being formed. Authors who wish to offer a paper should send the title and three copies of a 250-word abstract to their national group before 1 October, 1958. Abstracts should be in English or French. Each paper for discussion will be pre-printed in one of these languages. (The fourth topic would appear to have not reached the stage of practical application.)

After a preliminary selection, which will be made in October, authors whose abstracts are selected will be asked to put forward a full text for final selection. Instructions concerning the presentation of the papers will be supplied at the same time. Applications for attending the conference should be sent to national groups. In Britain the address is: The Honorary Secretary, Group B—Computation and Automatic Control, British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, London, W.C.2. (Optimum address length might enter the discussion under the second topic.)

An international exhibition of data processing equipment will be held in Paris at the time of the conference. Interested firms should get in touch with the UNESCO secretariat there. Visits will also be made to various factories manufacturing such equipment and to computation laboratories, in Paris and possibly neighbouring countries. (It is to be hoped that any existent machines of the type to be discussed under the sixth topic will take the opportunity to benefit by these visits.)

Summit Institutions

Is chemical engineering a fourth primary technology, distinctive and embracing as civil, mechanical and electrical engineering? The issue, in some measure, is to be put to the test by a discussion that will be heard at an Extraordinary Meeting of the Engineers' Guild to be held on Thursday, 25 September, at the Grosvenor Hotel, Victoria, London, S.W.1. The meeting has been called by the Guilds' General Council to consider a resolution which, in effect, will make corporate members of the Institution of Chemical Engineers acceptable for membership of the Guild, a qualification that has so far been restricted to the members of the three premier institutions. The debate is certain to revive in no uncertain manner the requests for admission of members of the Institute of Marine Engineers, the Institution of Structural Engineers and fellows of the Royal Aeronautical Society.

Letters to the Editor

I, TOO, LIKE AMERICANS

SIR, In the last of his stimulating and highly enjoyable articles on the American scene, Mr. E. P. Ward has grasped the nettle of the position of the corporation in American life, and confounded the witch-hunters of Organisation Men by giving it his qualified approval. To this I should like to add my support.

My support is based on the opportunity I was generously given during nearly two years' tenure of a Commonwealth Fund Harkness Fellowship to study that most difficult organisational field, research. It seemed that too much research in Britain was carried out in an atmosphere of embittered human relations: was there an answer to be found in the U.S.A.? Did one, in fact, want to find an answer? For there are those who consider that an element of frustration is essential to good research work: it drives the individual inwards to call on his own deep and possibly unsuspected resources. In research management seminars at Massachusetts Institute of Technology, and in residential conferences with industrial research leaders—in which I was privileged to take part and to act as group leader—this was one of the problems frequently touched on.

The conclusion to be drawn from many experiences freely related, and from the increasingly substantiated theories of motivation, was that conflict is not a necessary source of personal dynamic. Consequently, the effect of working within an organisation having harmonious personal relationships and management policies is not inevitably to smother individual integrity and independent action. Rather, by skilful management, each individual can feel the inner drive to use his maximum resources and, in so doing, he equates his own benefit with that of his immediate group, and with that of the corporation.

Certainly there still seems a place for the lone inventor, and, as reported in your columns recently, there are proportionately far more firms being started in the U.S.A. by one or two men, often to exploit a single invention, than here. But the field of important inventions which can be successfully developed to this stage individually is diminishing. An answer, if not the complete answer, to the problem of giving the individualist inventor or scientist scope and resources has been made by the big corporations, either by allowing a certain proportion of their staff to follow lines of investigation completely of their own choosing, or by allowing all to spend up to say 20 per cent of their total budgets on such projects. At the same time, many firms relieve their researchers of all administrative work, as Mr. Ward so well illustrated. I knew many men who worked under these circumstances, and there could be no doubt of their appreciation of working conditions that were superior, both physically and mentally, to any they were previously used to. More importantly, these were not stereotyped representatives of a machine society, but individuals whose special qualities were allowed to develop more fully. For much of our valued independence is, in fact, freedom to do character-stultifying chores, or freedom not to do them and suffer for it; this being almost the limit of choice open to us.

Would we benefit from an extension of these developments in Britain? This question touches another of the subjects of Mr. Ward's inquiries, that of the effects of liberal and purely technological educational programmes. An important factor in the flourishing of these comprehensive organisations in America is the ability of the average educated American to adjust himself into harmonious personal relationships in widely different situations.

Many persons concerned with education, both in the U.S.A. and here, maintain that too much time is spent in American school education in courses aimed at "life adjustment." I came into contact principally with the end product of this system, and was greatly impressed with the

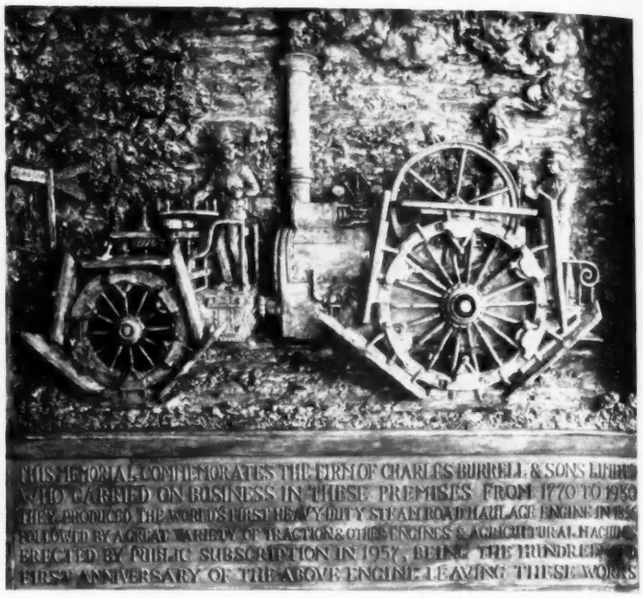
Automobile Engineering

PIONEERS OF STEAM TRACTION ON ROADS

Memorials to engineers are comparatively few, and to engineering firms still fewer, but the latter category has now received a notable accession by the unveiling at Thetford, Norfolk, on July 12, of a plaque commemorating Charles Burrell and Sons Limited, who, in 1856, produced there what is claimed to be the first heavy-duty road haulage engine.

The plaque, of alloy bronze, was designed by Mr. G. Moray Smith, of Norwich, from contemporary photographs of the engine, which was fitted with Joseph Boydell's patent wheels, forerunners of the chain tracks now in common use. It is a fine example of *cire perdue* casting and was produced in the Lambeth foundry of the Morris Singer Company Limited, London, S.W.8. It is affixed to the wall of what was formerly the general office building of Charles Burrell and Sons, in Minstergate Street, Thetford, and bears the cast inscription that "This Memorial commemorates the firm of Charles Burrell and Sons Limited who carried on business in these Premises from 1770 to 1930. They produced the World's First Heavy-duty Steam Road Haulage Engine in 1856 followed by a great variety of Traction & Other Engines & Agricultural Machines."

The memorial has been erected by public subscription, as the inscription also records, organised by a local committee of which the secretary and treasurer is Mr. Ronald H. Clark, A.M.I.Mech.E., of Diamond Cottage, Shotesham All Saints, Norwich. The Newcomen Society was represented on this committee. The plaque was unveiled by Mr. John W. Howlett, O.B.E., M.I.Mech.E., founder of Wellworthy Limited, the piston-ring makers, and a former Mayor of Lymington, Hampshire, who had served his apprenticeship in the works; part of it under Charles Burrell himself, who was nearly 90 when he died in 1906. Another Burrell apprentice, who will be widely remembered among engineers, was the late Mr. E. Bruce Ball, Wh.Sc., who was President of the Institution of Mechanical Engineers in 1939.


THIS MEMORIAL COMMEMORATES THE FIRM OF CHARLES BURRELL & SONS LIMITED
WHO CARRIED ON BUSINESS IN THESE PREMISES FROM 1770 TO 1930
THEY PRODUCED THE WORLDS FIRST HEAVY-DUTY STEAM ROAD HAULAGE ENGINE IN 1856
FOLLOWED BY A GREAT VARIETY OF TRACTION & OTHER ENGINES & AGRICULTURAL MACHINES
ERECTED BY PUBLIC SUBSCRIPTION IN 1957, BEING THE HUNDREDTH
FIRST ANNIVERSARY OF THE ABOVE ENGINE LEAVING THESE WORKS

Continuing Letters to the Editor

freedom that successful personal adjustment gave to participate in "opinion-making" or "decision-making" processes. For example, the course in nuclear reactor engineering at MIT consisted of coursework (plenty) done in one's own time, so that the lectures could be given over entirely to free discussion of the implications of the present work, or of opinions of the class members.

Quite frequently, Dr. Manson Benedict, a leading authority in the field, would give up his rostrum for a complete period so that one of the graduate students taking the course, having a particular interest in the immediate topic (he might be doing heat transfer research in another department), could develop his views in lecture form, followed by ruthless discussion. At Harvard, where I myself was undertaking a research project, the research students would be called upon to give short papers about their work, even during the initial stages, and subject their views to high quality criticism from other students and professors, who would not let considerations of false chivalry prevent exposure of errors. That this was done with such goodwill and with very valuable consequences was due to these easy relationships.

Absence of barriers to personal contact gives fruit not only in the organisational corporation and the research laboratory but in less structured informal meetings. In the Faculty Club at MIT, one could discuss esoteric shop or the fortunes of the Boston Red Sox with perfect strangers in equal freedom. Shortly after arriving in the U.S.A., my neighbour at the Club's lunch table introduced himself, inquired my name, and asked my opinion of the current economic situation. I expounded freely, drawing on my ten days' experience of the country and on the results of reading recent issues of the *Christian Science Monitor*.

He made some comments, expressed his interest and apologetically left to catch a plane; whereupon my other neighbour told me that I had been talking to Mr. Coolidge, president of the National Research Corporation and several other companies. I had laid myself wide open to what in Britain would be a quite irresistible stinging rebuff, but in the States a snub in such circumstances is unknown. The experiences quoted by Capricorn, in your issue of 4 July, of being a visitor to many concerns here and of being "put in one's place" too often, would, I am sure, have been remembered, had they occurred in the U.S.A., as times of stimulating discussion and useful contacts.

In short, Sir, I can only agree wholeheartedly with Mr. Ward's first title: "I like Americans." I hope his tact and skill in presenting his views will prevent the all-too-often result of my enthusiasm, typified by a young and widely-travelled colleague's reaction to my invitation to see some American colour slides: "No thank you: whatever you tell me I can't believe anything good about those people." I hope he has read Mr. Ward's series. They will do good if at least they make us think.

Yours very truly,
D. G. WILSON.

Turbine Design Department,
Ruston and Hornsby Limited,
Lincoln.
15 July, 1958.

ALUMINIUM DERRICK

SIR, Thank you for your article "Aluminium Derrick for Mobile Prospecting Work" which is much appreciated (ENGRG., 11 July, '58, p. 37).

We notice that in your penultimate paragraph you qualify the mention of our alloy B51S as "a Duralumin-type alloy." Strictly speaking, this is not correct, since the group of alloys to which the general name duralumin is often given, particularly on the Continent, is of the copper-bearing type, whereas B51S (BS 1476: HE 30) is of the magnesium-silicide type. Another consideration is that, in this country, Duralumin is used as a trade name, regardless of the type of alloy, by one particular aluminium supplier.

We know you will not mind our drawing your attention to this point, being only too well aware of the complexity of nomenclature in the aluminium industry.

Yours faithfully,
R. F. TAYLER.

Publicity Division,
Northern Aluminium Company Limited,
Banbury, Oxfordshire.
15 July, 1958.

AUTOMOBILE DIVISION I.MECH.E.

Visit to Shrivenham

The annual summer gathering of the Automobile Division of the Institution of Mechanical Engineers was held on Saturday, 19 July, 1958, at the Royal Military College of Science, Shrivenham. With the chairman of the Automobile Division, Mr. R. C. Cross and Mrs. Cross, were the President of the Institution, Air Marshal Sir Owen Jones and Lady Jones, and some 450 members and friends.

After a welcome by the Commandant, Major-General J. W. Hackett, and the Dean, Dr. S. J. Davies (a past-chairman of the Automobile Division), the laboratories of the four departments of the College, Mathematics and Physics, Chemistry and Metallurgy, Civil and Mechanical Engineering, and Electrical and Instrument Technology, were inspected by the visitors.

In addition to the apparatus used in the engineering and science degree courses at the College, a wide range of equipment devised for the specialised post-graduate courses and for research was demonstrated. This included a working rocket motor, a new type of heat exchanger, tyre and vehicle research apparatus, subsonic and supersonic flow channels, computers and electronic apparatus as used in guided weapons, fuel testing, metallurgical examinations, the irradiation of plastics and other aspects of nuclear science. These exhibits were the subject of considerable discussion.

Getting Men to Work Together

The Case of The Bad Mixer
Criticism and Plain Speaking
Stress and Strain in Human Relations
Three Human Reactions: Aggression, Submission or Escape
Anxiety and Escape
Authoritarian Barriers to Communication

These six articles by Z. M. T. Tarkowski, B.Sc., which have recently appeared in ENGINEERING, have aroused considerable interest. They are now available as a reprint entitled *Getting Men to Work Together*. Copies are obtainable from the Publisher, ENGINEERING, 36 Bedford Street, London, W.C.2, price 4*s*. post free.

Continuing **Automobile Engineering**

TWIN CAMSHAFT ENGINE FOR MGA

The MGA sports car gains in performance and moves into a new capacity class with the introduction of a 1,600 cc (97 cu. in) twin camshaft four cylinder engine and Dunlop disc brakes on all four wheels as optional alternatives to the standard pushrod engine and drum brakes. Besides increased power, the engine speed range is extended. Peak power of 108 b.h.p. is delivered at 5,600 r.p.m. but the engine gives 97 b.h.p. at 5,000 r.p.m. and is still giving 100 at 7,000 r.p.m. Because of this there is no change in the axle ratio, although alternative ratios for axle and gearbox are available for competition use. Maximum torque is 105 lb-ft at 4,500 r.p.m., equivalent to 165 lb per sq. in b.m.e.p. Bore and stroke are 75·4 mm and 88·9 mm, respectively.

It is understood that works' test drivers with the new engine have recorded average accelerations of 0 to 100 m.p.h. in 30·4 seconds and have reached 110 m.p.h. in 37 seconds.

The engine started as an adaptation of the existing pushrod unit for the last TT race but differed more extensively as development proceeded. The chain drive to the camshaft is contained in an alloy casing at the front. A pinion on the crankshaft drives a half-time wheel on a stub shaft which also carries a skew gear to drive the ignition distributor. From there chains take the drive to the overhead camshafts. The new power unit is slightly longer than the push-rod engine, and to save space the radiator header tank has been moved back and mounted on the engine alongside the exhaust camshaft. It is connected to a small casting housing the thermostat with three-way connections to the cylinder head, radiator block and water pump by-pass. Pump, fan and generator are belt driven. Two S.U. carburettors are mounted at a slight angle to the horizontal, and on the opposite side four separate exhaust ports feed into twin manifolds which group together the first and fourth, and second and third cylinders. Compression ratio of the new engine is 9·9 to 1. It will run on premium grade fuel, but 100 octane is preferable.

An optional alternative for the MGA is a 1,600 cc twin camshaft engine.

The Dunlop disc brakes are a new type using segments of friction material instead of the usual circular pads, and the wheels are perforated discs with central lock nuts. With purchase tax, the improvements add £270 to the British retail price.

NEW OPEL KAPITAN *Popular Model from German Subsidiary of General Motors*

A redesigned version of the Opel Kapitan, the largest motor car manufactured by the General Motors German subsidiary, is now being produced. As usual nowadays, it is longer, wider, lower and more powerful than its predecessor. Since the war, more than 260,000 Kapitans have been built and over 60 per cent of them exported. The new model is already being delivered overseas. The length is only increased by a little over an inch, but the height has been cut by 2⅜ in. An increase in wheelbase has allowed the seats to be dropped 3½ in lower in the car, and the driving vision has been maintained by a new falling bonnet line 2¾ in lower than before. The size of the propeller-shaft tunnel has been kept within acceptable limits by tilting the power unit and using a two-piece propeller shaft with a rubber-insulated centre bearing. A better utilisation of the interior width has given an extra 2 in on the width of front and rear seat cushions, and the spring cases have been redesigned. Seats have foam-rubber overlays, and a safety roll over the top of the front seats protects the faces of the rear-seat passengers. The new dimensions are: wheelbase 110·25 in; length 187·5 in; width 70·25 in; and height 59 in.

The suspension is completely orthodox, but the front coil springs now have a progressive action; non-parallel axes for the upper and lower "wishbones," as employed on General Motors cars in the United States since 1955, effectively counteract nose diving when braking sharply. An anti-roll bar has also been added to the rear half-elliptic springs and these modifications, coupled with the longer wheelbase and lower centre of gravity, should appreciably improve the handling characteristics. The steering column now has a flexible joint to prevent transmission of road shock and vibration. Ball joints on the ends of the wishbones act as steering pivots.

The brakes have two leading shoes at the front, and the friction lining area is slightly increased. Pedal leverage has been modified to reduce the pressure required. The wheel size remains unchanged at 13 in but the tyre section has been increased to 6·70 in. The spare wheel is recessed inside the rear wing contour.

The engine is basically the same 2,475 cc short-stroke (80 by 82 mm) six-cylinder push-rod unit as before, but the compression ratio has been increased from 7·1 to 7·5 to 1, raising the gross power from 82 to 96 b.h.p. (SAE rating) at 4,000 r.p.m. Figures quoted for installed power are now 80 b.h.p. at 4,100 r.p.m. against 75 b.h.p. at 3,900 r.p.m. A torque of at least 127 lb-ft is available all the way from 1,400 to 2,400 r.p.m., making this largely a top-gear car. The gearbox with steering column lever and synchromesh for all three speeds is unchanged, but a Borg-Warner overdrive is now an optional extra. With this fitted, the axle ratio is 4·22 to 1 instead of 3·9. The maximum speed is said to be 88 m.p.h. with a fuel consumption of 24 to 26 miles per Imperial gallon, improving to 29 m.p.g. with overdrive. The tank capacity has been increased to 12 gallons and the filler is now on the rear panel.

The Kapitan is a boldly styled car with obvious American influence, and it is exceptionally well equipped. There is a choice of cord or plastics upholstery in eight colours with a selection of 27 exterior colour schemes. A cleanly-designed new instrument panel includes a strip-type speedometer with a trip recorder. There are parking lamps, a light inside the big trunk, mirrors on the sun visors and a steering lock.

The Luxus version at a higher price has reclining front seats with fully-adjustable back rests, reversing lamps, fog lamps, lights for glove box and engine, a cigarette lighter, a screen washer, swivelling ventilating panels in the rear as well as in the front doors, an anti-dazzle mirror, pockets in front doors, parcel nets on the backs of the front seats and a red warning light in the edge of the driver's door. The weight of the new models at 2,900 lb is increased by about 132 lb but the extra power should cope with this. The price of the standard model is up by about £76.

The redesigned Opel Kapitan is larger, wider, lower and more powerful than before.

GERMAN CARS AND THE COMMON MARKET

The German motor manufacturers are now tuning up for the fiercer competition expected when the Common Market comes into being. In the first quarter of this year 373,200 vehicles came off the assembly lines, 25 per cent more than in the same period last year. At the same time exports rose to 185,000 vehicles. One sign of the times is the recent merger brought about by Daimler-Benz buying a majority holding in Auto-Union. These two companies employ 75,000 workers between them and have a combined annual turnover greater than that of Volkswagen. The merger is expected to mean that Auto-Union will continue to specialise in small cars and that Daimler-Benz will not now enter this field. The American subsidiaries have been engaged in a bout of investment spending as a part of their policy of bringing in European-made small cars rather than manufacturing them at home. Opel, owned by General Motors, has carried out a big re-equipment programme at its Rüsselsheim plant. The German Ford company at Cologne has also gone in for changes, including some in its top management. Another agreement is that NSU will at first sell and later assemble and part manufacture Alfa-Romeo cars.

Meantime Volkswagen continue out in front. Output has risen by 50 per cent over the past 15 months and is now around 2,200 vehicles a day. Freer trade with Italy and France whenever it comes will mean additional sales. Across the Atlantic, American motor-car output has taken a very slight turn for the better. Nevertheless the small car invasion is being taken very seriously. It is said that on dark nights men are writing up on the walls of Detroit the poignant slogan "Volkswagen go home."

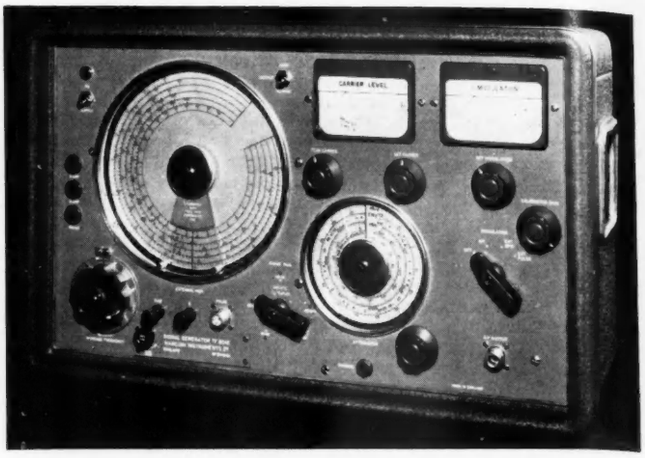
Plant and Equipment

SIGNAL GENERATOR

The TF 801C is the newest member of the range of amplitude-moderated signal generators produced by Marconi Instruments Limited, St. Albans. Its salient features include a frequency coverage of 10 to 500 Mc/s with 0·5 per cent tuning accuracy, and a built-in crystal calibrator. The company claim that it has a very low level of spurious frequency modulation, and a 50 ohm output with a v.s.w.r. of less than 1·2.

The carrier level is continuously variable from 0·1 microvolt to 0·5 volt, and 1,000 c/s sine-wave amplitude modulation may be applied internally at any depth up to a maximum which is at least 30 per cent and, at most carrier frequencies, reaches 90 per cent. An alternative output yields a maximum of 1 volt modulated or 2 volts unmodulated, at most frequencies.

Modulation may also be applied externally. For sine-wave inputs the modulation frequency range is 30 c/s to 20 kc/s and the modulation depth is monitored up to 90 per cent. For pulse inputs, the modulating circuit is d.c. coupled and will accept pulses at repetition frequencies up to 50 kc/s. Modulation is applied to the power amplifier, without disturbing the operating parameters of the master oscillator.



The range of the TF 801C signal generator is 10-500 Mc/s, tuning accuracy being 0·5 per cent.

TRANSFER MACHINE WITH 51 STATIONS

Recently, opportunity was given by the CVA Group to see a 51-station in-line transfer machine that has been constructed in their No. 6 factory at Hollingbury, Brighton. It is claimed that this machine is the longest in-line transfer unit to be built in this country by a single manufacturer. As with most of the firm's special-purpose machines, it was built under the licence agreement with Kearney and Trecker of Milwaukee, although the design work was carried out on this side of the Atlantic.

The machine is in two main sections, the first of which carries out milling operations on the component, and the second drilling and tapping. Between the two is a link-up corresponding to four stations, which allows the two units to be used independently. It also enables components that have been milled to be banked in emergency. Overall, the machine measures 140 ft in length.

In the milling section, use has been made of the travelling milling heads to actuate the transfer arms, which are arranged to swing clear during their return stroke. On the drilling section this arrangement is not possible, so the transfer arms are operated by a hydraulic cylinder, and are mounted overhead rather than at the side. Idle stations at intervals allow access to the unit heads.

Throughout the whole assembly, standard units have been used as far as possible to give both flexibility and low cost. Examples are the unit milling heads which are themselves mounted on standard lengths of hardened and ground slideways; these in their turn rest on standard bases, which contain storage tanks for the hydraulic oil. The drill heads are similarly built up, the gearboxes which house the trains for the multispindles being made from standard top and bottom sections with the requisite number of standard spacers in between to accommodate the gears for each particular head. All hydraulic pipework and electrical conduits are mounted externally for ease of maintenance. Hydraulic cylinders and rams provide the power for traversing the milling heads.

To guard against damage from broken drills or obstructed holes, conventional probes and blow-out units are mounted at appropriate places along the drilling section of the unit. Should an obstruction occur, the machine is stopped and prevented from performing another cycle by a breaker switch in the electrical circuit.

Two modes of operation are possible; first, each cycle can be started by the operator after he has loaded the component on to the guide rails; and second, the cycle can be continuously repeated, which would be the case if the components were loaded automatically. It is also possible to operate the two sections independently, and, for setting up, there are separate controls for each head unit.

WELDING PVC

A machine for the welding of p.v.c. sheets up to 50 in long and 0·004 in to 0·005 in thick has been developed by H.F. Industrial Services Limited, 317 High Road, Wood Green, London, N.22, by the addition of an auxiliary pneumatic closing unit to their basic Acme No. 1 machine. Two operators are required and four plungers must be depressed simultaneously to start the cycle. This ensures that the operators' hands are clear of the press.

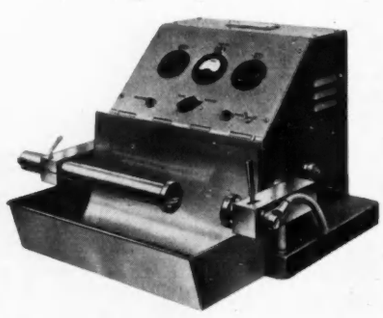
Seals up to 50 in long can be made on this p.v.c. welding machine.

The pneumatic unit is designed to operate in two stages; first an auxiliary low pressure ram brings the press into position and then the main ram applies the full working pressure while the weld is being made. This arrangement is claimed to give economy in the use of air.

PORTABLE CRACK DETECTOR FOR PRODUCTION INSPECTION

Shown in the accompanying illustration is the latest addition to the range of portable magnetic crack-detection apparatus made by Radalloyd Limited, Glen Road, Leicester. Both circumferential and longitudinal cracks can be detected at one setting of the test piece—the set being designed to give current flow up to 1,200 A or magnetic flux to over 700 oersteds through a 2 in air gap. The high resolving powers of the instrument are such, it is claimed, that it will clearly reveal a circumferential crack on a 1¼ in diameter test piece that could not be detected optically when magnified 500 times; and in stressed links with hardened ends, the molecular change at the quench point is clearly shown.

The instrument illustrated has been designed as a compact high-output bench machine for the rapid production testing of small to medium-sized components, and will take workpieces up to 16 in long. It is fitted with a 5 kVA transformer. Apart from the meter, control switches, and indicating lights, all the machine components are mounted on a cast ribbed aluminium base. All electrical components, the makers state, are, very conservatively rated. Additional accessories, such as long cables with heavy bronze clamps, and an alternative type of stand with motor-driven pump, ink tank and piping are available.



With this magnetic detector, circumferential or longitudinal cracks can be detected at one setting.

HYDRAULIC PRESSES

Several improvements are claimed for the new range of four-column hydraulic presses now being made by Charles S. W. Grigg Limited, Hanworth Road, Hounslow, Middlesex. All models have a working pressure of 2 tons per sq. in and use hydraulic pumps and ancillaries supplied by Towler Brothers (Patents) Limited.

Among the changes are a quicker lowering of the platen to the working position, made possible by the use of a submerged pre-fill valve; a very fast return stroke; built-in oil tank and pumps; and better rigidity by using very long guides. The new design will be used in presses with capacities ranging from 50 to 50,000 tons.

Companies in the News

Motor Vehicles Abroad

The motor vehicle boom on the Continent of Europe has gone on without a break for a full decade. The increase in output during 1957 was substantial in almost every case. Two annual reports were published recently, those of Aktiebolaget Volvo, the largest manufacturers of cars, lorries and tractors in Scandinavia, and of the Société Anonyme Des Automobiles Peugeot, who make one of the most popular cars in Europe. Volvo's output rose from 50,682 in 1956 to 57,585 in 1957, despite the effect of petrol restrictions imposed as a result of the Suez crisis. In common with most of the other leading European manufacturers sales to the United States rose sharply (approximately doubled) and exports as a whole increased by 42 per cent. An agreement concluded with the Government of Norway to employ Norwegian companies as sub-contractors in return for an increased import quota of Volvo cars resulted in raising sales in that country by 3,000 to nearly 5,000. Sales to the United States totalled 10,414 units (nearly all passenger cars), concentrated in the Western States. The company are now taking steps to set up a distributor network in other parts of the country.

Peugeot continue to find it difficult to supply the demand for their cars. Output in 1957 was nearly 18 per cent greater than in 1956, exports accounting for 43 per cent of the total. "The most striking progress," states the company, "was made in Scandinavia, Central Europe and African countries outside the French Union." The average daily output rose to 693 and continues to increase. In December it had reached 725 units. But delivery delays of two years or more are still being quoted to French buyers and there is a tendency for the volume of orders still to exceed that of deliveries.

The manner in which Continental manufacturers have made use of the boom to re-equip does them credit. Both Volvo and Peugeot say they have achieved their progress in 1957 by taking advantage of the latest technical developments and processes. They are becoming formidable competitors.

Reduced Expansion in Forgings

Two of the larger manufacturers of steel forgings and stampings in the country, Ambrose Shardlow and Company Limited and Daniel Doncaster and Sons, are nearing the end of their expansion and modernisation programmes. Ambrose Shardlow's extension to their forge at Sheffield is almost completed and should, according to Mr. T. P. N. Burness, their chairman, make "a further contribution to greater efficiency and increased capacity in the production of drop stampings." The lessons these companies have learnt since the war are the dangers of over-dependence on the motor industry, so leading them into other fields. Shardlows have begun to manufacture larger-sized crankshafts up to 10 ft 6 in length for the medium-sized stationary locomotive and marine-engine markets. The supply of steel forging billets is now adequate and the main problem has shifted from the supply of materials to the reduction of costs.

Daniel Doncaster have experienced difficulties in utilising the capacity built up at their Sheffield works for meeting demand from the Ministry of Supply. The sharp and sudden reduction in defence orders last autumn left about half this capacity idle, and it has not proved easy to find other markets. Capital expenditure during the current financial year (ending March 1959) will be substantially reduced, although it will include the building of research and development facilities for testing heat-resisting and other alloys. This will operate as a central service for the company's four works.

Mr. R. Steel, chairman of Daniel Doncaster, told shareholders that there had been a further reduction in demand since last April, which led to cuts in production last month. He warned that his company must be affected by falling industrial activity and that "trade is not so good at the moment." The likely reduction in motor manufacturers' purchasing schedules later this year must have a severe impact on this industry, particularly as demand from other sources is tending to fall.

Simms Top the Million

Group profits of £1·1 million, representing an increase of over £130,000 on 1956, were declared by Simms Motor and Electronics Corporation. This is the new name of the group (formerly known as Simms Motor Units Limited) reflecting the many changes that have taken place in the past two years. The number of subsidiaries and associated companies has now grown to 15, and products range from oil injection equipment to hair clippers (Horstmann Ltd.), and railway signalling equipment (A. R. Parsons & Co. Ltd.). They have recently acquired Motor and Electronics Corporation Limited (M.E.C.) thereby implementing what their chairman, Mr. G. E. Liardet, describes as a policy of diversification and expansion. M.E.C. products include many types of electronic components, switchgear and accessories, for television, radio, radar and telecommunications, as well as vacuum ware, transmission couplings and other products which supplement Simms' previous activities in the field of motor vehicle components, general engineering, ventilation and heating, plastics, oil burners and domestic products.

The demand for fuel injection equipment for diesel engines has continued to grow and a large volume is being shipped to the United States. Mr. Liardet claimed that the group were the world's leading manufacturers in this field. New products, including a hand starter for diesel engines and a turbo-charger, have been added to the range and capacity is being increased. Considerable attention will continue to be given to ideas for new products and the examination of existing products for new applications and reductions in manufacturing costs. A product development division has been set up.

Future prospects are considered to be fairly good, notwithstanding marketing difficulties arising from rising costs and increased competition for a reducing volume of business. Mr. Liardet rightly pins his faith for continued expansion on "stability of wages and increased productivity." If inflation can be held in check and the value of the pound is stabilised, he expresses the hope that next year's results may be equally satisfactory.

Civil Engineers Overseas

The excellent reputation gained by British consultants and contractors in overseas countries since the war has gained this industry a foothold in almost every market. Major firms have proved that they can be fully competitive with their foreign rivals and many of them have now a big stake in foreign business. This is not, of course, without risks as some of the companies have pointed out in their annual reports. The chairman of John Mowlem and Company Limited recently told the company's shareholders that they had decided against accepting a variation of the terms of their contract with the Iranian Government for the reconstruction of 1,400 miles of roadways, because the new conditions requested "might have involved us in considerable financial risks." This was before the current crisis and may mean the end of an 8-year contract "to advise on the design, and supervise the repair and reconstruction of some of the main Iranian highways." Significantly, perhaps, there are very few contractors—Balfour Beatty is one—who had major overseas work before the war, and who still operate abroad. There is no doubt that the risks are considerable, even in politically stable and friendly areas.

Mowlem at present operate in East Africa, Jamaica, Trinidad, British Guiana and Hong Kong. John Laing and Son (Holdings) Limited, who have recently emerged as the major road constructors at home (for some time Tarmac Limited seemed to have a near monopoly of this work), are working in Canada, in the Central African Federation and in the Union of South Africa. Frederick S. Snow and Partners, who were responsible as the "consulting and co-ordinating engineers" for Gatwick airport, have been appointed consultants for Kuwait airport, which is to be "the most modern airport in the world." Kuwait airport could become the principal stopping off point for the area—possibly becoming a major link between African and Asian services—and will almost certainly be the air centre for oil men. While the political future of the Middle East must remain uncertain for some weeks, it is less likely that Anglo-American influence in the southern half of the region will be seriously challenged, if only because the oil must continue to be sold mainly in the Western Hemisphere. British influence in Kuwait is strong and both British engineers have done much work there in recent years.

The chairman of John Laing, Mr. W. K. Laing, spoke of the future outlook for the contracting industry "with some concern." Difficulties, mainly financial on the part of Governments, have led to a reduction of future development programmes. Meanwhile, the British road programme is getting under way and Laing are playing a leading part. A major factor in their success is their ability and growing reputation for getting contracts completed on or before time.

Safety Belt Thrown Overboard

The shipbuilding industry have decided to wind up National Shipbuilders Security Limited (N.S.S.) which was formed in 1930 to deal with the problem of surplus shipbuilding capacity. In this announcement of the industry's decision, the Shipbuilding Conference state that N.S.S. "undoubtedly contributed substantially to the survival of the shipbuilding industry in the United Kingdom." They were empowered to purchase redundant and obsolete yards and to restrict the purchase of sites for shipbuilding purposes. The activities of the N.S.S., they say, brought about a healthier relationship between capacity and demand and thereby improved the economic basis on which the industry carried on through a long period of extremely difficult years and in face of acute foreign competition.

The Conference point out that much of the criticism of N.S.S. was misinformed, implying that their function was not a restrictive one. During the war two former N.S.S. sites were re-opened for the building of ships on Government account and 58 vessels, totalling over 250,000 d.w. tons were completed. Since the war no new sites have been opened, but the industry achieved a considerable expansion of capacity by the adoption of new shipbuilding methods and techniques, and by the re-equipment and modernisation of existing yards.

The decision to wind up N.S.S. was almost certainly taken to comply with the Government's Restrictive Practices Act. The Conference described the company as "an almost unique and certainly successful exercise in rationalisation." Its winding up raises many questions concerning redundancy and the fluctuations in demand which must arise in the shipbuilding and engineering industries. The Locomotive and Allied Manufacturers' Association (then the LMA) had a similar task in the steam locomotive building industry. It is difficult to conceive other ways to deal effectively with an industry's overheads during periods of intense competition with foreign firms, particularly when a major proportion of the industry's output is for export. Some kind of national organisation to reduce waste and safeguard individual firms' ability to compete may impose itself.

POWER FROM THE SEA

Temperature Differences Made to Provide Electricity and Fresh Water

FOR many generations power-hungry engineers have turned greedy and longing eyes to the oceans that cover more than three-quarters of the earth's surface. The sight of so much energy being wasted in the waves and the tides was almost more than they could bear. Many efforts did they make to harness the sea, but only limited success was ever obtained. Around our shores can still be seen remains of tide mills built hopefully to snatch the precious power that was going virtually for nothing, but very few of the schemes had more than a brief existence.

Still the process continues, and still schemes are being put forward. The Severn barrage scheme has only recently once again come into prominence, and in France the plan for the Rance Estuary is rapidly being transformed from paper into fact. The main difficulty that all tidal schemes have to face is that the power is not provided regularly—man is dependent on nature and the laws of things decree that the tides change their times from day to day, with the result that their energy is not always available at a time when man is in most need of it. This inevitably leads to some storage system being required—a complication that engineers could well do without.

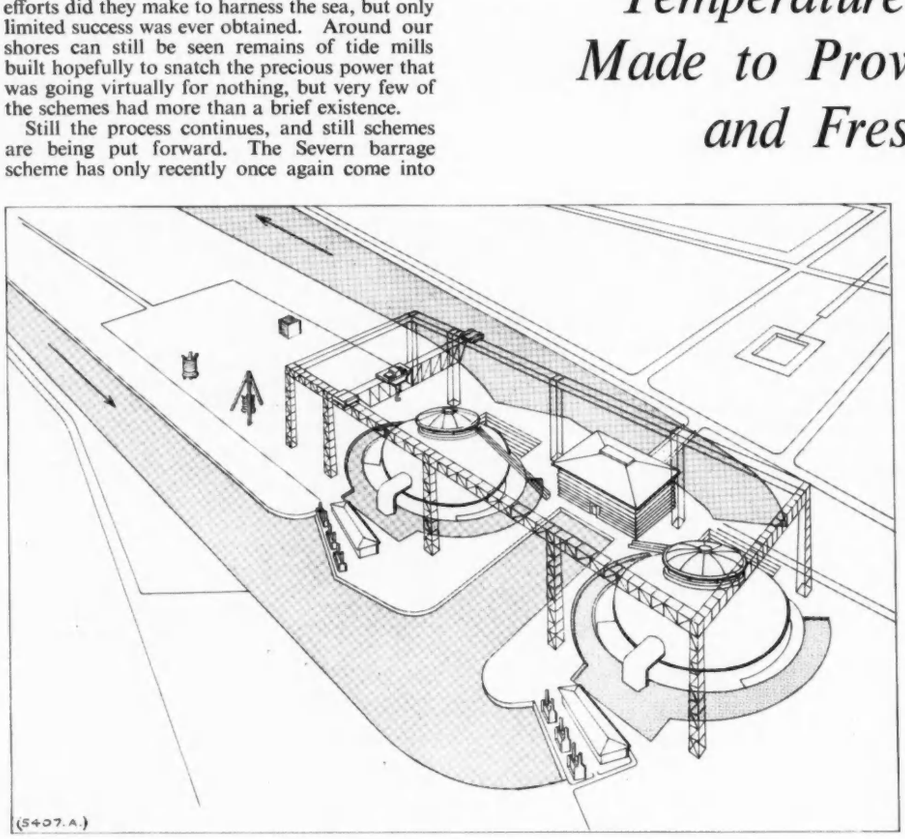


Fig. 1 Perspective drawing of two 3,500 kW generator sets with the associated warm water canals.

Quite different in conception is another scheme which also has been developed mainly by French engineers. This depends on the fact that there exists in some parts of the oceans a large temperature difference between the surface and the depths of the sea. A temperature difference always implies a possible source of power—if only some means can be found of degrading the hot body to the same temperature as the cold one and converting the heat given out in the process to work. Theoretically it does not seem to matter whether one cools a large mass through a small temperature range or a small mass through a large one but, from the point of view of obtaining useful work, the " quality " of the heat matters a great deal. Naturally, in the case of the sea only " low-grade " heat is available, which governs the methods that can be used to extract work from it. Another natural limitation is that large temperature differences in the sea only occur in a relatively few places, and these mostly in the tropics. However, as it is also in these under-developed tropical areas that the need for cheap power is great, this limitation is not so bad as it might appear at first sight.

Put in its briefest form the principle involved in the French plan (which has progressed far beyond the drawing board stage) is to evaporate the relatively hot surface water under a fairly high vacuum, pass the vapour through a turbine to obtain the useful work, and use the cold water from deeper levels to cool the condenser. The evaporation would be equivalent to distillation and the condensate would be a continual supply of sweet water for domestic or industrial use. Moreover, there would also be a considerable concentration of the excess brine and this could form the first step in a chemical industry.

The first suggestion of applying Carnot's principle to bodies which have only a small temperature difference was probably put forward by d'Arsonval, but experiments were first undertaken by Claude and Boucherot between 1926 and 1934. These experiments led to the construction of a turbine set at Ougrée in Belgium, followed by trials at Matanzas in Cuba in 1929 and 1930. During these trials Claude demonstrated a set in operation before an official Cuban jury. However, the plans were not pursued, mainly due to financial reasons.

The idea was taken up again in 1941 on the joint initiative of the Ministère de la France d'Outremer and of the Centre National de la Recherche Scientifique, which formed a technical committee under the chairmanship of Professor Ch. Jacob. The reports of this body led to the formation in 1948 of the company " Energie des Mers " which undertook to carry out studies for a power station.

The site selected for the station was on the Côte d'Ivoire in the region of Adibjan. The reason for this choice was that off the coast is an area known as " Le Trou sans Fond," where the sea bed descends to a depth of 468 metres at about 4 km from the shore. This depth offers a temperature difference of 20° C between the surface waters and those at the bottom. The problems posed were the laying of the conduit to draw the cold water from such a site in the open sea, and the technical difficulties involved in the construction of a plant that would operate under the low vacuum (approximately 0·04 kg per sq. cm abs.) necessary to generate the steam for the turbine.

Very little was known at that time about evaporation under vacuum at low temperatures, and preliminary trials were carried out at Bercy under the direction of Mr. L. Nisolle, professor at the Ecole Centrale des Arts et Manufactures. The work was done on a semi-industrial scale with a plant capable of evaporating and condensing 6,000 kg of steam per hour. At the same time tests were carried out on the de-aerating of the water, a feature that assumes great importance with the low pressures in use. In spite of using de-aerating vessels, the quantity remaining was so great as to render the power consumption of the ejectors prohibitive, and so it was decided to use the compressor developed by Rateau. This consumes only about one-fifteenth of the power output of the turbine. Details of this work as well as a description of the design of the plant were given in a paper presented to the Fourth World Power Conference in 1950.

GENERATOR EQUIPMENT

For the installation at Abidjan, it was decided to have two independent sets, each of 5,500 kW gross output. After allowing for the power consumed by the auxiliaries (including the water pumps, etc.) it was estimated that the net output of each would be 3,500 kW. The general plan of the plant is shown in Fig. 1.

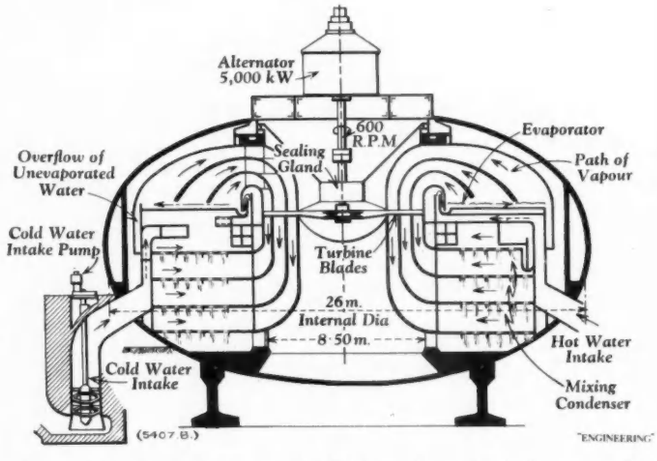


Fig. 2 The hot surface water is fed from the centre to the evaporation trays. In this design the vapour is condensed by jets of cold water.

With the exception of the alternator, the complete assembly is housed in a reinforced concrete casing made as nearly spherical as possible in order best to withstand the external pressure of 10 tonnes per sq. metre. The thickness of the shell would be 25 cm and the construction would be carried out in sections using simple metal forms. The concrete can be rendered vacuum tight either by a water-cooled metallic cover or by a plastics-based coating.

The upper half of the envelope contains the evaporators which are divided radially in sections (Fig. 2). The hot surface water is fed to them from the centre, and any excess passes over the weir into the annular collecting trough. This excess water will be richer in salts than normal sea water and so could be used as the first stage in the production of chemicals. The sections are arranged opposite the ducts that will take the vapour to the turbine. After passage through the rotor the vapour is led to the condensers in the lower part of the shell.

The consensers shown in Fig. 2 are of the " mixing " type and so the combined extract would be salt since the cooling water comes from the sea. However, at an increased cost of about 7 per cent of the total sum, surface condensers as in Fig. 4 could be used which would then yield some 7,000 tonnes of sweet water each 24 hours. It is probable that if the scheme reaches fruition this latter plan will be adopted.

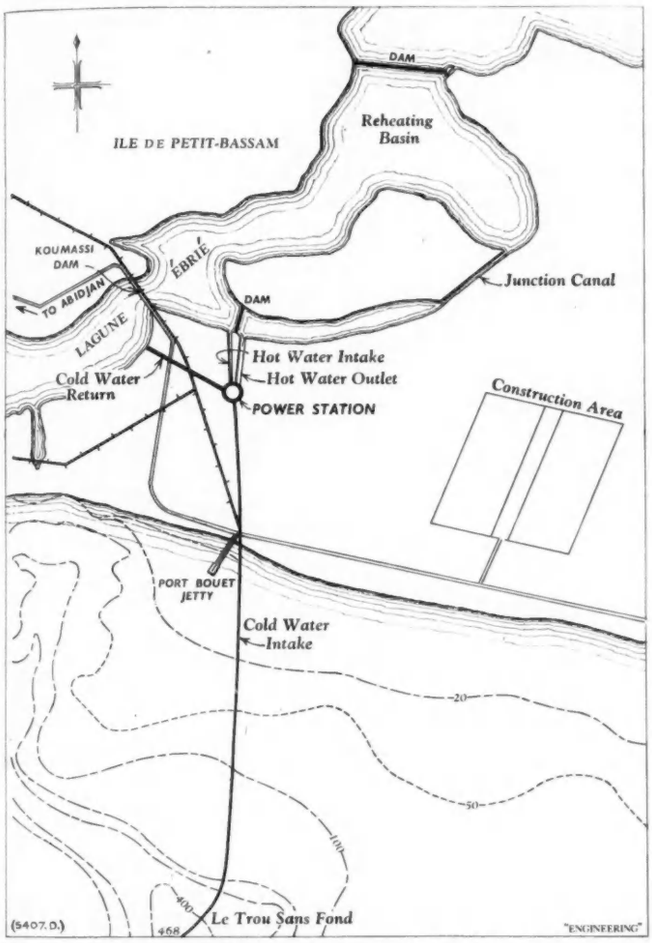


Fig. 3 Site of the Abidjan project showing the canals and ducts for the water supplies.

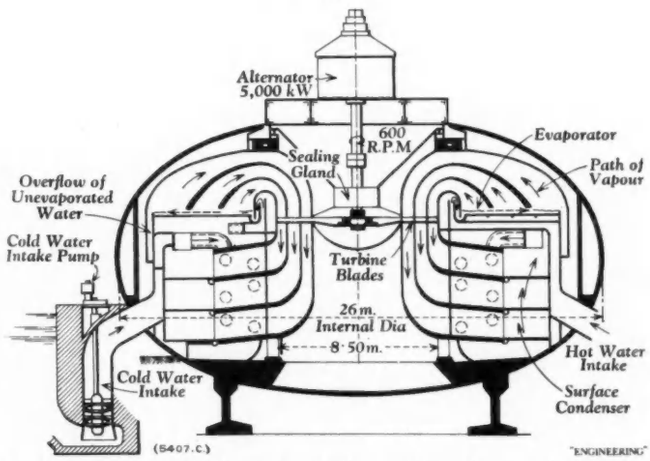


Fig. 4 When a supply of sweet water is wanted, surface condensers can be used to keep the distillate separate.

The design of the turbine offered some difficulties as the conditions were beyond any met with in normal practice. For the very small temperature drop existing between the evaporator and the condenser only a single reaction wheel with the blade angle increasing from the hub to the periphery was possible. Examples had been made with the required pressure drop but, with the techniques available at that period, the energy produced was less than the power calculated, and was approximately equal to that needed for proper operation of the auxiliaries. The final choice was for a rotor 8 metres in diameter to revolve at 600 r.p.m. This would be direct coupled to the alternator, the shaft passing through a sealing box so that the alternator would not be subjected to the vacuum within the shell. The weight of the alternator would be supported directly on the concrete shell, while that of the turbine shaft and rotor would be carried by a bearing hung from the shell by a cone-shaped structure.

Apart from the generator sets themselves, the land works include the construction of the inlet duct for the cold water, and the inlet and return canals for the hot surface water. The former would be a concrete pipe 2·50 m in diameter and 1,600 m long from the station to the shore, and the latter would both be canals to the Ébrié lagoon. In addition there would be a return canal for the cold water from the condensers. In the case where the condensate consists of sweet water only, separate provision would have to be made for its extraction for irrigation purposes and the like. Fig 3 shows the general site plant.

COLD WATER INTAKE

The construction of the canals to and from the lagoon offer no unusual difficulties (they could easily be cut with a bulldozer) but with the intake from the " Trou sans Fond " it is far otherwise. Indeed this problem was one of the main causes of the troubles experienced by Claude in his experiments in Cuba already mentioned. Various points were immediately apparent. The pipe must be sufficiently flexible to follow the contours of the sea bed and yet strong enough to withstand the forces encountered in launching it; some means of launching must be found which would give complete control during the positioning whatever sea might be running at the time; and the pipe must be capable of withstanding the forces of the sea and remain in position after it had been launched.

To meet these requirements it was decided to make the pipe in three sections. The first, which would extend from the shore to a depth of 14 m, would be of sheet steel made up of sections bolted together with flanges. This would carry the duct through the surf region. The second would go from the 14 m level to 110 m and would be about three-quarters of the entire length of the duct. It would be semi-rigid, being made up of 50 m lengths of thin plate welded over a metal frame and linked together by flexible joints of reinforced rubber 2·50 m long. The third and last section would extend to a depth of 420 m and would also consist of metal and reinforced rubber elements to accommodate the slope of the sea bed, but the importance of the rubber elements would be greater. At the end of this third section would be the cold water intake.

The laying of the first section offered little difficulty, but for the second and third, which would almost certainly have to be laid in a choppy sea, special floats would be needed from which the pipe could be suspended by cables. The flexible joints would allow lengths of 300 m to be laid at a time from a small number of floats and without the necessity of exact co-ordination between them in the process. The joining of these sections would be carried out in shallow water by divers.

The final flexible section would have to be rather different from the others in that it would need more anchorage points and would use some auxiliary buoys. It is absolutely essential that the strains imposed by the action of waves on the floats should be kept to a minimum during the handling of the pipe, and that control must be complete to allow accurate positioning during the laying.

In 1946, therefore, l'Organisme d'Etudes (run by the C.N.R.S.) constructed a section of pipe 150 metres long to find a solution to this problem. The pipe was made up of three elements each 50 metres long joined together by two flexible units, the diameter being 2·5 metres. Eight rigid steel sections bolted together made up the 50 metre lengths. At the same time four wave resisting floats were built consisting of a tower-like superstructure containing the winch and the cable handling gear, mounted on horizontal caissons. These latter were almost entirely submerged with the result that the effect of variation in wave height was very small.

A series of trials was made off Brest in September, 1947, during which the vertical movements of the float when loaded with the pipe did not exceed 30 cm for a wave height of more than 2 metres. Although this proved that the pipe could be satisfactorily manoeuvred even in a choppy sea, it was not possible to carry out laying tests owing to lack of mechanical equipment and also the great distances of towing necessary in order to find suitable depths.

Since soundings of the sea bed at the Trou sans Fond had revealed slopes of 40° it was thought advisable to repeat the trials on the actual site. At the same time the method of transport and of laying could be tried out. For these tests more powerful means were available, and specially designed engines were used that had been tried out on scale

Continuing Power from the Sea

Fig. 5 As slopes of 40° had been observed under water, it was necessary to have a flexible pipe. Here an element in reinforced rubber is being tested for flexibility.

began. Following the return of the dry season, work was resumed and after the last winches had been put into position and the personnel trained at the lagoon between October and December, the convoy of four floats and the pipe was ready for the first trip to sea. This took place on January 31, 1954.

The passage through the canal of Vridi was safely accomplished and the floats again showed their stability in the waves and fairly violent currents encountered at the opening to the sea. A few minutes later, however, a fault in one of the suspension cables made it necessary to lower the pipe prematurely. Several weeks later after the unlucky lengths had been recovered, the cause was identified and a new cross-bar designed and made, on which that error could not be repeated.

While the work of recovery was going on, trials were carried out on the flexible end-section intended to form the intake. The pipe proved more flexible than had been hoped and it was therefore certain that it would be able to follow closely even a very uneven contour (Fig. 5). At last on April 17, 1954, in a fairly rough sea and a fresh wind, the convoy of floats carried the flexible section (which had been made rigid for the occasion) out of the canal of Vridi and proceeded to the Trou sans Fond without incident. Here they remained for eight hours and then returned through a sea with waves that reached a crest height of 2 metres. To complete the tests still possible in spite of the advancement of the season, on April 17 a convoy of floats carrying a weight equivalent to an element of semi-rigid pipe, proceeded to the Trou sans Fond and there lowered it to a depth of 117 metres and later raised it again. This concluded the series of trials for the season. The next step was the joining of two lengths of pipe at sea—easy enough in a dead calm, but experience had shown that calm days were extremely rare.

Using the experience gained during the earlier trials a prototype float incorporating some major improvements was constructed and tried in deep water off Toulon before being sent out to Abidjan for inclusion in the convoy. On arrival a trial was made of joining two lengths of pipe in 15 metres of water in the lagoon. The two sections measuring 102 metres in length were assembled on a launching slip and taken out into the Ébrié lagoon, by two convoys of four floats (including the new prototype) until a suitable depth of water was reached. The operation was carried out by ex-Naval frogmen in the presence of M. Longchambon, the president of the High Commission for Scientific Research, and formerly Secretary of State for Scientific Research. After instructing the surface personnel in approach manoeuvres and the frogmen in the joining of the special coupling, the initial union was completed in three hours with all the expected trials and errors. A repetition carried out next day was completed in 45 minutes at the rate of one bolt per minute per diver. The operation in progress is illustrated in Fig. 6. The operation of unbolting and separating the two sections was quickly finished and the convoy was ready to repeat at sea the successful work of the lagoon.

The junction was successfully made at sea on 11 December, 1955, with waves running up to 1·5 metres at the crest, after an unexpected fault had been remedied. After putting out to sea it was found that one of the stabilising tanks was not tightly shut and a leak had occurred. The operation of changing the suspension float was embarked upon and safely completed, which added much to the handling experience of the crews. The actual joining of the sections proved easier at sea than in the lagoon on account of the better visibility and of the residual movements of the swell. Less than an hour was needed, again confirming the rate of bolting as one bolt per minute per diver.

During the same series of tests one section of pipe was laid on the bed at a depth of 40 metres and left there for three consecutive nights together with its floats, for which it served as an anchor. Close examination after recovery

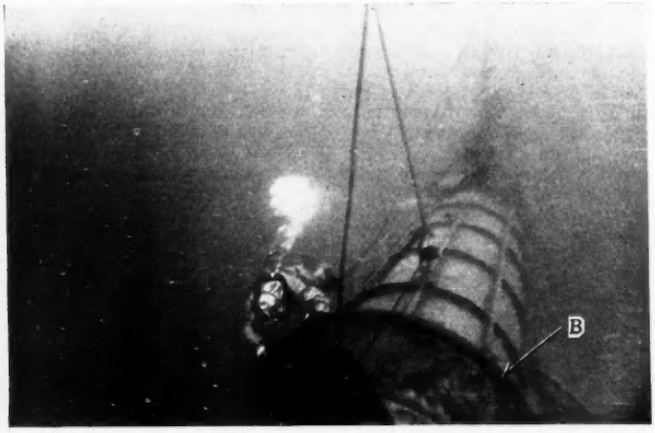


Fig. 6 Under-water junctions were made by frog-men after the sections were brought together and aligned by their centring cones. The locking device was first closed and then the diver bolted up the sealing clamp "B."

Fig. 7 After laying tests at sea at a depth of 40 m, one of the pipe sections was raised for checking. It was in perfect condition after being immersed for three nights.

models. In particular the stabilised floats had the advantage over those of earlier trials in having 10 ton motor-driven winches with double reeving and variable speed. Moreover, in these later versions the towers had been dispensed with and the working platform rested directly on the caissons. These floats can be seen in Figs. 8–10. The experimental length of pipe used was again 150 metres but this time only 1·75 metres in diameter, made of three equal elements with reinforced rubber joints. By varying the number of joints, a pipe could be produced that would follow any contour. The work of erection began in 1952 and was completed in March, 1953.

By then the season suitable for making frequent excursions to sea was far advanced and there was scarcely time to stabilise the first two floats and to mount the winches before the rains

Fig. 8 Passing between the moles of the Vridi canal with a length of 1·75 m diameter pipe.

COMPARISON OF NOTCHED BAR TESTS

By A. W. Johnston, A.M.I.MECH.E.

A variety of tests is used to assess the notch-toughness of steels for structural purposes. Test pieces for three of these tests, the Izod test, the Charpy U-notch test and the Charpy V-notch test, are described in B.S. 131: 1933. In two of three of these tests, in addition to the standard form, subsidiary standard test pieces have been devised for use where the material form necessitates a smaller test specimen.

The advantages to be derived from the inter-correlation of the results of standard and subsidiary standard tests of various kinds need no emphasis, particularly as the bulk of past experience relates to test pieces of the standard forms. Considerable effort has been devoted to attempts to establish such intercorrelation, and a suggested relationship between Izod and Charpy U-notch test results was published in B.S. 131. In general, however, such attempts have met with little success, and a review by Fettweis* suggests that this results largely from the failure to take into account the difference between cleavage and shear fracture.

An investigation comprising over 1,200 tests has been undertaken at the Mechanical Engineering Research Laboratory to compare results from the above three types of test, using both standard and subsidiary standard test pieces, over the ductile-brittle temperature ranges of six steels. The materials were three mild steels (0·07 per cent C, 0·10 per cent C and 0·15 per cent C) and three alloy steels (2½ per cent Ni Cr, 3½ per cent Ni Cr and 0·4 per cent C, 1 per cent Ni).

The notch profiles were formed by grinding and the tests were made at temperatures ranging from 110° C to 196° C in a standard 120 ft-lb Izod impact testing machine and a standard 30 kg-metre Charpy impact testing machine.

The principal conclusions which could be drawn from the results are as follows:—

(1) No simple relationship appears to exist between the results of the Izod test, the U-notch Charpy test and the V-notch Charpy test that can be applied to all six of the materials tested.

(2) The relationship between Izod and U-notch Charpy test results proposed in B.S. 131: 1933 is satisfied only by the results from the three alloy steels. A different relationship of similar form was found for the three mild steels.

(4) No simple relationship appears to exist between the absorbed energies for 10 mm by 10 mm test pieces and 10 mm by 5 mm test pieces, for any of these three tests, that will apply to all six materials.

(5) An approximate relationship of linear form was found between 10 mm by 10 mm and 10 mm by 5 mm Izod test results for four of the steels tested.

(6) From 10 mm by 10 mm test pieces from all the steels, the transition from ductile to brittle fracture for V-notch Charpy test pieces occurs at a higher temperature than for the U-notch test pieces. This applies also to the three mild steels when tested using 10 mm by 5 mm test pieces.

(7) Transition curves obtained respectively from Izod and Charpy U-notch tests extend approximately over the same range of temperature.

(8) The energies absorbed by test pieces cut from the test bars in a transverse direction are in general lower than those from test pieces cut in a longitudinal direction.

The full report of the work, which is summarised briefly above, gives detailed results and includes 38 diagrams showing the temperature transition curves for the test materials obtained from the different tests and indicating relationships between the results where they appear to exist.

Acknowledgement.—The work described was carried out as part of the research programme of the Mechanical Engineering Research Board and this note is published by permission of the Director of Mechanical Engineering Research, to whom application may be made for copies of the complete report.†

* F. Fettweis, *Die Kerbschlagprobe: Entwicklung und Kritik*, vol 2, pp. 625 to 674 (1929). (Translated by L. Emmerich and D. P. Klier, Pennsylvania State College.)

† Apply to Director, Mechanical Engineering Research Laboratory, East Kilbride, Glasgow, quoting reference AB Div. No. 9/58.

Measuring Steel Strengths in the Ductile Brittle Range

JET PROVOST FILMED

In February this year the Secretary of State for Air announced that the Royal Air Force had decided to establish *ab initio* flying training on jet aircraft, after evaluation trials on pre-production Jet Provost aircraft had demonstrated the advantages of this form of training. Up till now, primary training has been carried out on light piston-engine aircraft, changing over to jet aircraft at the "basic training" stage. When the Jet Provost comes into full operation next year—it is now in production—it will provide both primary and basic training for all R.A.F. pilots. One interesting result of the evaluation trials is that, although the ultimate percentage of pupil pilots who fail to "make the grade" is much the same in both old and new training regimes, in the "all-through" jet training programme the great majority of the unsuitable pupils are detected in the primary stage and failures in advanced training are very much rarer than on the earlier system.

Many overseas air forces are greatly interested in the R.A.F.'s adoption of the "all-through" jet trainer. Recently, a demonstration Jet Provost—which is powered by an Armstrong Siddeley Viper turbojet—has been carrying out a very successful tour of the South American countries. The makers of the aircraft—Hunting Aircraft Limited, Luton—have produced an attractive colour-sound film of the Jet Provost, demonstrating some of its performance capabilities, illustrating the equipment with which it can be fitted, and emphasising the economies which it can effect in pilot training. Finally, pre-production Jet Provosts are shown in routine service at one of the regular R.A.F. flying training schools.

Particularly pleasing are the few shots taken from the cockpit so that the onlooker sees what the pilot would see—in fact, rather more "audience participation" might well add to the sales potential of the film.

Continuing Power from the Sea

did not reveal any sign of failure of either the suspension or the stabilised floats (Fig. 7).

The only point then remaining before the project could be definitely laid out was the testing at greater depths of the various devices used. This trial, which had never before been attempted, was successfully carried out when the length of semi-rigid pipe was lowered to the bed at 300 metres (the height of the Eiffel Tower). During the trial difficult conditions were encountered as the waves were sometimes three metres high. On the same day a trial was made of dragging for the pipe from a depth of 200 metres. From the first attempt the equipment worked perfectly, proving the possibility of recovering the pipe even under very difficult circumstances. Various stages are shown in Figs. 8, 9 and 10.

These trials, which ended in April, 1956, completed the experimental side of the work. The scheme has been proved practicable, but it still awaits Government approval before being put into operation. Running costs would be minute, for the sea water would cost nothing and the pumps required would be driven from the alternator output, leaving 3,500 kW available for each set as net power. In addition, approximately 7,000 tonnes of sweet water would be produced each day and an enormous quantity of concentrated brine would be available for chemical recovery. There is also the possibility of a food source, for large numbers of fish would be drawn into the feeder canals where they could be easily caught.

Fig. 9 One of the floats in a swell 2 m high. The stabilisers restricted the vertical movement of pipe to 30 cm.

Fig. 10 The two end floats brought close together while the pipes were being joined under water.

Atomic Review

By-Products and Waste Products

THE economy of an industry is closely interwoven with the market value of its by-products, its ability to recover and re-use production materials and the efficient disposal of its waste products. The industrial development of nuclear reactors is no exception. Radioisotopes are by-products with a rapidly growing market, fuels re-enriched with fissile uranium and plutonium can be used again, but the disposal of highly active waste and large volumes of active effluent from the chemical processing plants servicing the reactors, present serious problems.

Increased Use of Radioisotopes

The potentially enormous benefits accruing to mankind as a result of the increasing use of radioactive isotopes are not always appreciated. As a by-product of nuclear energy, these radioactive elements are now commercially available for use throughout the world as research tools in the chemical and engineering industries, for the improvement of agriculture, in combating diseases, and the protection of food and animals from bacteria and insect infestation. It has even been suggested that the major advances in science and technology resulting from the use of isotopes will have a far greater impact on our standard of life than the use of atomic energy for commercial power generation.

Britain is exporting between £200,000 and £300,000 worth of radioisotopes each year; more than any other country in the world. Fifty-two countries purchase isotopes from us. The total annual sales of artificially made isotopes by the United Kingdom Atomic Energy Authority's, Research Establishment at Harwell and the Radiochemical Centre, Amersham, is about £600,000 per year; and trade is increasing at the rate of about 12 per cent per year. (The UKAEA also operates large radiation facilities at Wantage, referred to in ENGRG. vol. 183, 1957, p. 802.)

This information was given by Mr. W. G. Busbridge of the UKAEA Isotope Division when speaking on "Radioisotopes and their uses" at the recent FBI Conference on Nuclear Energy (ENGRG., 25 April '58, pp. 525-7). In addition, Mr. Busbridge gave an interesting account of the application of isotopes, and the following review is based mainly on what he had to say, and on the OEEC publication, *Applications of Atomic Science in Agriculture and Food* (Feb. 1958), a report of the mission to the United States, sponsored by the European Productivity Agency.

The majority of radioisotopes so far produced have been artificially made by placing normal stable elements such as sodium, iodine, phosphorus and cobalt in a nuclear reactor, thereby bombarding them with neutrons. A variety of nuclear reactions then occur, the simplest of which is one in which an extra neutron is added to the nucleus thus upsetting the proportion of neutrons to protons and rendering the element unstable or in other words, radioactive. The rate at which production occurs is a function of a number of variables, firstly the flux, or intensity of neutron bombardment in the reactor, secondly, the capture cross-section of the nucleus or area within which a neutron must pass to be captured by the nucleus, and thirdly since the radioisotope starts to decay as soon as it is formed, the half-life of the particular isotope. For example, it is necessary to irradiate stable cobalt for two years in the BEPO reactor at Harwell to produce the radioactive cobalt 60. Research reactors such as BEPO (United Kingdom) and HIFAR (Australia) having a high flux density and with special facilities to enable samples to be inserted or removed while the reactor is in operation, are usually employed for isotope production.

Fuel Elements as a Source of Isotopes

With the growth in number of nuclear power stations a new and vast source of radioisotopes becomes available from the fission products of uranium. These fission products, which are generated in the uranium fuel rods, give rise to a mixture of about 280 different isotopes of about 40 elements. Over 200 of these are radioactive, with half-lives varying from fractions of a second to millions of years. Some of the more useful isotopes, such as caesium 137, promethium 147, cerium 144, strontium 90 and technetium 99, may be recovered by the chemical processing of spent reactor fuels. It is interesting to note that the United States Atomic Energy Commission will this summer have a pilot plant operating at the Oak Ridge National Laboratory for the separation and extraction of these isotopes from fission products, and have announced reduced prices for the five isotopes mentioned above, which have comparative long half-lives, in anticipation of increased production from the new fission product plant.

The half-life of an isotope is important when considering its application; a simple definition of this characteristic being the time taken for half of its atoms to disintegrate. It is often necessary to plan experiments so that at the end no radioactivity is left, thus avoiding biological hazards or dangerous waste products. The process of disintegration is unaffected by chemical or physical change, and proceeds independently of temperature or pressure changes, or of any chemical reactions that the isotope or any of its compounds may undergo. Typical examples of the radioisotopes available and their large range of half-lives (given in parentheses) are as follows: sodium 24 (15 hours), iodine 131 (8 days), phosphorus 32 (14 days), cerium 144 (282 days), promethium 147 (2·6 years), cobalt 60 (5·3 years), strontium 90 (25 years), caesium 137 (30 ± 3 years), carbon 14 (5,600 years), and technetium 99 (212,000 years). The latter two isotopes are of interest since they remain virtually unchanged in any experiment likely to be planned and therefore no calculation involving decay rate is necessary.

Mr. Busbridge, in his paper, pointed out that one of the chief merits of the radioisotopes, as used in what are termed "tracer techniques," is the special facility they offer for detection in extremely small quantities. The amount of radioisotope is usually given, not in grammes, but in curies. The curie, originally defined as the activity of one gramme of radium 226, is now defined as $3{\cdot}7 \times 10^{10}$ disintegrations per second. Thus, with an instrument capable of detecting or measuring one disintegration per second, it is possible to detect or measure one thirty-seven-thousand-millionth of a gramme ($2{\cdot}7 \times 10^{-11}$ g) of radium. Thus, for example, taking phosphorus 32 which, with its half-life of 14 days is disintegrating 40,000 times as fast as radium and with the atomic weight of 32, has seven times as many atoms to the gramme, we find that, at one disintegration per second, it is possible to detect or measure about one ten-thousand-billionth of a gramme (10^{-13} g) of phosphorus 32. This is about a billionth of the smallest quantity which is detectable by chemical means.

Radioisotopes Aid Research

Professor A. Charlesby has reviewed recently some developments in the application of radioisotopes (ENGRG., 23 May '58, p. 648), but a few further examples of the use of specific isotopes will emphasise the importance of these new substances in research. Mr. Busbridge referred to the use of sodium 24 which, when introduced into the blood stream of the human body, enabled one to determine its rate of flow and the total volume of blood. The short half-life of this isotope (measured in hours) ensures that no radioactivity is left in the blood after the investigations have been completed. Medical research into the functioning of the thyroid gland has been assisted by experiments with radioactive iodine such as iodine 131, by measuring the uptake and secretion of this element by the gland. Hormones and other compounds can be labelled with this isotope so that their metabolism and function in the body can be studied. In the fight against cancer, caesium 137 can now be used, as well as the expensive and limited cobalt 60 sources, for the therapy of deep growths (teletherapy). New facilities for the separation of caesium 137 from the waste fission products of reactor fuel rods are expected to reduce the price of this isotope to about 10s. per curie by 1960 and to ensure a supply of one million curies for the hospitals. In dentistry a radiograph of the patient's jaws may be more conveniently obtained using a thulium 170 source than by X-ray methods, which involve longer exposure of the tongue and mouth.

Tracer techniques using radioisotopes are applicable to the study of flow systems of all kinds such as leak detection in long-distance water or oil pipe lines, hydraulic flow in pipe networks, rivers and irrigation systems; they are used to measure the movement of sand and pebbles on beaches, and the siltation of rivers and harbours; also for measuring bulk flow of materials in factories, for example, cement and fertiliser, and for determining the efficiency of mixing various ingredients in the manufacture of such diverse substances as cattle food, chocolate, building hardboard. Gaseous tracers, notably krypton 85, are used in ventilation tests and to detect and measure leakages such as might occur in an underground coal gasification system.

An interesting application of radioactive iodine was reported recently by the Australian Atomic Energy Commission. This was to determine the way in which warm water from a small power station mixed with, and passed through, a disused reservoir used as a cooling pond. By adding small quantities of radioactive iodine to the warm water from the power station, ensuring that the concentration was kept within the tolerances for drinking water recommended by the International Commission on Radiological Protection, the circulation of the "labelled" water was traced with Geiger counters and scintillometers throughout the breadth and depth of the lake. The lake covered an area of 40 acres and contained about 200 million gallons of water, the warm water from the condensers being carried to the far end of the lake at the rate of 15,000 gallons per minute and cooled as it spread out through the lake. Water from the lake is pumped back from a point near the power station. Valuable data were obtained in this way for the design of the cooling ponds required for the large power stations planned for the New South Wales coalfields.

Processing Spent Fuel Elements

Reference has already been made to some of the useful radioisotopes which it is now possible to extract from the irradiated fuel of nuclear power reactors; fissile uranium and plutonium are of course other products which have special uses. Details of some of the chemical purification and extraction processes have been described previously in Atomic Review (14 Feb. and 11 April '58). Speaking in Brussels on 17 May at the 1958 British Electrical Conference, Sir John Cockcroft, member for scientific research of the UKAEA, announced that his Authority, besides building an extensive new plant for converting uranium ore into metallic fuel elements, would be enlarging the chemical separation plant to provide a central fuel-element processing facility for the whole of the United Kingdom nuclear power programme.

In a paper "Fabrication and Processing of Fuel Elements," given at the FBI Conference on Nuclear Energy, Mr. C. Buck, chief engineer, chemical plant design office, UKAEA, described the plant and processes at the Windscale Works. The procedure was to discharge the irradiated fuel elements into skips, using remote handling gear. The skips, in heavy shielded containers, were then taken to a deep pond where the skip was removed from the container, the water pro-

viding the biological shielding. The fuel elements were stored in the pond for some months to enable short-life fission products to decay, thus reducing the shielding and chemical problems in subsequent stages of the process. After storage, the skips pass to an under-water de-canning machine which strips the can from the uranium rod, the former being removed to an active waste storage and the uranium transferred in shielded containers to the chemical processing plant.

The first stage is the removal of the highly active fission products and to separate the uranium and plutonium streams. This is carried out in large concrete cells up to 180 ft in height and having walls varying between 2 ft and 4 ft 6 in in thickness. The used stripped fuel elements are dissolved in nitric acid contained in thick stainless-steel vessels and the Butex solvent extraction process applied so that the uranium and plutonium taken up by the solvent leave at the top of the extraction column, and the bulk of the fission products in solution in nitric acid leave at the base and pass to a plant where, after evaporation, they are permanently stored. The radioisotopes caesium and strontium are extracted from these fission-product solutions. Mr. Buck reported that for the erection of the Windscale chemical plants a large proportion of the country's stainless steel output was used; the argon-arc process was also applied for the first time in welding the stainless-steel pipes, and to ensure 100 per cent soundness in the welded joints, gamma-ray examination of the welds was carried out using specially prepared irridium 192 sources.

Fig. 1 TRIGA, a training, research and isotope production reactor will be exhibited by the United States at the Geneva Conference next September.

Storage and Disposal of Active Wastes

One of the major problems in the operation of an active chemical processing plant is the storage or disposal of waste products. Wastes of a low order of activity are usually contained in large volumes of liquor arising in the later stages of the separation plant or from other sources such as cooling ponds. Such wastes are treated in flocculation plant, the resultant sludges containing most of the activity being removed and permanently stored under water. The treated liquors are carefully checked to ensure that the remaining activity is within a specification agreed with the health and fishery authorities, and then pumped out to sea through pipe lines which ensure discharge at a distance of about 2 miles from shore. Here prevailing currents dilute and dispense the activity and prevent local contamination of marine life or concentration on the sea bed.

Sea Dumping

With the increase in size and numbers of nuclear power stations, as well as other reactors used for research purposes, and the possibility of their development for ship and aircraft propulsion, the problem of treatment and disposal of reactor waste products becomes more and more important. Already concern has been expressed regarding the consequences to be expected from the disposal of large quantities of radioactive materials in the sea. Of course the main concern in this case is the possibility of contaminating edible seaweed, fish, shell fish and other marine life which later may reach human beings directly or indirectly.

One result has been to stimulate the need for ocean research to discover the main facts about the circulation of water in the deep oceans, as distinct from the surface currents which are depicted on charts, and to seek more information about the effects of radioactive materials on marine populations. Some requirements and proposals for research have been submitted by the United States National Academy of Sciences and the National Research Council, Washington, D.C., in their joint report "The Effects of Atomic Radiation on Oceanography and Fisheries (Publication No. 551).

Notes and News

Uranium for Sale

The United States Atomic Energy Commission announced last month that domestic producers of uranium ore and concentrates could make private sales both to home and foreign buyers. As a result of this action American industry will be able to compete with other countries for the fast growing market for nuclear fuel. Some 18 uranium mills are now operating and it is expected that these, together with others planned, will cover demand for the next few years both of the USAEC and commercial users. The United States now has agreements for co-operation in the peaceful uses of nuclear energy with some 12 countries. Meanwhile, north of the border, Canada's uranium mines have recently been authorised to sell on their own, any surpluses that they might have above their contract with the Government Agency, Eldorado Mining and Refining. Up to now the agency held a monopoly of uranium sales. Exports will be subject to a permit from the Atomic Energy Control Board and the Department of Trade and Commerce. These may be issued for individual sales up to 250 lb for use in testing and research. Sales to countries which have no agreement for co-operation with Canada are limited to 2,500 lb.

Arrangements for selling uranium abroad have also been made in South Africa. The South African Minister of Mines has announced that the Combined Development Agency will not purchase more than 6,200 tons of uranium ore from South African mines during the year starting 1 July. Any uranium output above this may be sold elsewhere. The figure of 6,200 tons for annual purchases ensures that plants will continue to operate at about their present rate. At present some 23 of South Africa's gold mines are producing uranium.

Isotope Producing Reactor

TRIGA, a new American training, research and isotope producing reactor, is shown in Fig. 1. It was previously mentioned in Atomic Review last 6 December. Located at the bottom of a 20 ft well, the core is covered by 16 ft of water which serves as a shield. A reactor of this type will be in operation throughout the second Geneva international conference on the peaceful uses of atomic energy, to be held from 1 to 13 September. The reactor produces useful quantities of radio-isotopes of 62 of the first 82 elements.

General Atomic, the American firm which developed TRIGA, describe it as a novel concept of homogeneous reactor, in an alloy of uranium-zirconium, hydride serves as fuel and moderator. Designed for academic, medical and research use, it has a power rating of 10 kW, but during initial tests at the John Jay Hopkins Laboratory, where the prototype is located, it was successfully operated at 100 kW. Another TRIGA is to be installed at the University of Arizona, Tucson.

Thorium Recovery Plant

The contract for the engineering and construction for what is believed to be the world's first thorium recovery plant has just been awarded by Rio Tinto-Dow Limited to Humphreys and Glasgow (Canada) Limited. The plant will be located on a site adjacent to the Algom Quirke Mine at Blind River, five miles north of Elliot Lake. Humphreys and Glasgow are still working on final engineering plans for the new plant but initial field work is expected to start immediately. The firm will be responsible for the design engineering and construction of the plant itself and for the installation of the special equipment and machinery needed for the processing of thorium concentrates, thorium sulphates and thorium oxide. In this work Humphreys and Glasgow will be adapting on a commercial scale a process evolved by Dow Chemicals in smaller pilot plants. It is expected that plant operations will be underway by January, 1959, with the plant operating at capacity by May, 1959.

Uranium in Britain

The part played by the Atomic Energy Division of the Geological Survey in the search for uranium is little known because of the security measures that have applied until comparatively recently to information on the production of nuclear raw materials. Last year the division, acting on behalf of the UKAEA, undertook an airborne radiometric survey of West and Central Cornwall. Results of this survey have so far been interesting. Several of the anomalies recorded are sufficiently marked at surface to merit pitting, trenching and exploratory drilling to prove the extent of the mineralisation underground. The area to be covered by airborne survey will be extended this year to cover the remainder of Cornwall, and much of Devon and Somerset. Any areas which seem to justify closer examination will be investigated by ground parties equipped with portable scintillation and Geiger-Muller counters. In addition to this air reconnaissance survey, the division is undertaking the examination of abandoned mine workings in Cornwall where small amounts of uranium are known to occur. Only surface, or near surface, examination has hitherto been possible but reconnaissance drilling has recently started and will continue on an increased scale during the summer season. The division may later expand its survey to cover other areas in which uranium mineralisation might occur; for example, North and Central Wales, North England and the Southern Uplands of Scotland.

Handling Radioactive Fuel Cartridges

The servicing of reactors, particularly where

Continuing Atomic Review

faults arise, requires special maintenance techniques involving remote operation. The United Kingdom Atomic Energy Authority have devised an apparatus for removing radioactive fuel cartridges that become lodged inside reactors such as those at Windscale and Calder Hall. The apparatus, which employs a television camera for viewing the operation, has been built by Sir W. G. Armstrong Whitworth Aircraft Limited, Coventry, and can operate at depths up to 60 ft below the top of the biological shield. The complete machine consists of a Marconi camera, grab and light mounted on an actuated boom, which is carried in a retractable split pillar. The pillar can be lowered to reach all levels of the discharge void in reactors of this kind. The grab and camera are shown in operation in Fig. 2. A derrick headgear controls the lowering and lifting of the pillar and boom, which hangs vertical for access and removal. The headgear includes a Marconi television monitor, control unit, position indicating dials, self-winding cable drums and hoist, as can be seen in Fig. 3. The pillar can rotate through 180°, the boom can tilt to 90° and the camera itself can rotate through 240° and tilt up to 130°. The television component is a type BD871 vidicon television channel specially made by Marconi's Wireless Telegraph Company for closed-circuit applications. Only 4 in in diameter, the camera is cylindrical in construction, and automatic stops are provided to prevent it being damaged or lost in collision with obstructions.

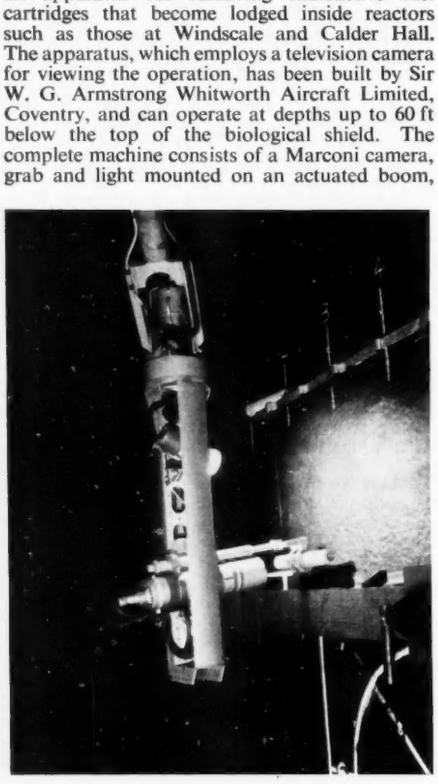


Fig. 2 Radioactive fuel cartridges lodged inside reactors such as those at Windscale and Calder Hall may be handled remotely by a grab and television camera unit built by Sir W. G. Armstrong Whitworth Aircraft Ltd., for the UKAEA.

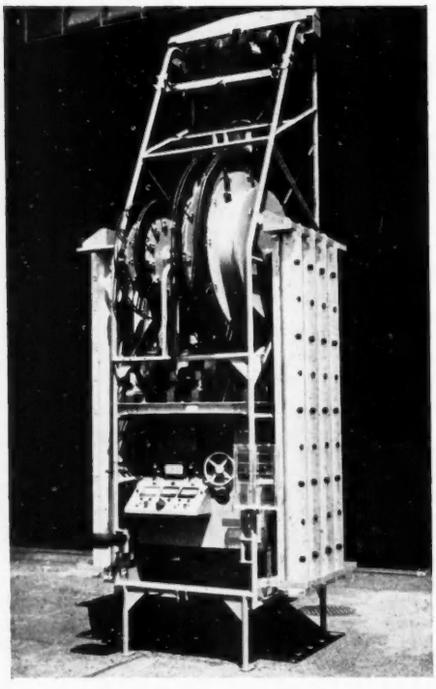


Fig. 3 The headgear of the fuel cartridge handling mechanism includes a Marconi television monitor, control unit, position indicating dials and self-winding cable drums.

In the Windscale piles, when the cartridges are discharged they fall from the graphite face into a space between the face and the concrete biological shield. However, after major discharging, some cartridges usually lodge on the arms of the scanner gear—used to transmit vital data from inside the pile—or on ledges in the discharge void. At present this situation is tackled by knocking off or otherwise removing the cartridges using long tools through four $9\frac{3}{4}$ in diameter inspection holes and 4 in diameter burst slug detection holes. Because of the scanner gear itself, there are certain areas of the discharge face which cannot be seen through any of these holes. With the new apparatus, the boom carrying the camera, with automatic focus lens, is lowered into the void through one of the $9\frac{3}{4}$ in diameter access holes on top of the pile. It can be focused on any area in the void and the picture is monitored from the top of the pile. The grab, secured to the camera casing, can be closed at the focal point to remove the cartridge.

Depleted Uranium for Sale

The Atomic Energy Commission has removed prohibitions on non-nuclear uses of uranium and has made depleted uranium from Commission stocks available for sale on an unclassified basis. (Depleted uranium is material from which a part of the fissionable uranium 235 has been removed; it contains less than the 7 tenths of 1 per cent by weight of uranium 235 present in natural uranium.)

Plutonium for Military Use

The Secretary of State for Scotland, Mr. John Maclay, was asked recently about the extent to which the atomic station at Hunterston, Ayrshire, was likely to be used for the production of atomic material for military purposes. It was pointed out to him that an article in one of the national newspapers, indicating that plutonium was to be manufactured there for military use, had caused considerable local alarm, especially as raw material for atom bombs was to be produced in a large industrial centre, not very far distant. Mr. Maclay said that the Government were solely concerned with the possibility of securing additional sources of military plutonium should the need arise. He could not forecast what use, if any, would be made of the Hunterston station in such circumstances.

Springfields Extension

The extensions to the UKAEA Springfields factory at Salwick, Lancashire, have been opened recently. New equipment for the processing of uranium ore to produce fuel elements is nearly complete and should be in operation in a few months. The production of the new plant is four or five times that of the old, but it will be two or three years before the complete project is working.

Nuclear Fuel Research

Following a ceremony, the building of a Fuels Technology Center at the Argonne National Laboratory, Lemont, Illinois, U.S.A., is now to be put in hand. The United States Atomic Energy Commission has allocated 10 million dol for the construction of the Centre.

Speaking at the ceremony, Dr. F. G. Foote, director, Metallurgy Division at the Argonne Laboratory, said that the two main objectives which had prompted the erection of the new Centre were to concentrate under one roof many of the activities at present scattered in numerous buildings in the neighbourhood, and to expand very considerably the facilities and man-power devoted to the development of plutonium as a reactor fuel. In point of fact, continued Dr. Foote, the second objective was the prime reason for the construction of the building.

Organic Reactor Fuels

Requirements for a homogeneous organic reactor fuel have been considered. Dibenzoylmethane complexes of uranium and thorium fulfil some of these conditions; they are soluble in terphenyls and very stable to radiation, but their thermal stabilities are insufficient for a reactor fuel. (Alan E. Comyns: Atomic Energy Research Establishment, Harwell.)

Measuring Soft Beta Rays

The Model 6000 Dynacon Electrometer is a radiation measuring system made by the Nuclear-Chicago Corporation designed particularly for the measurement of soft beta emitting isotopes. Measurement is based on the principle that a radioactive sample in an ion chamber produces an ion current proportional to the activity of the sample. The Dynacon amplifies this minute proportional current for a clear and precise display of the sample activity on the panel meter or on a chart recorder. The system accepts and measures gas, liquid, and solid samples. It is the ideal instrument for making continuous gas flow measurements as in plant and animal uptake and metabolism studies. The Dynacon measures with high precision sample activities which vary by a factor of more than ten-million to one; from less than 5×10^{-11} curies to 10^{-3} curies of activity without the use of absorbers, standards, or sample dilution. The inherent stability of the system provides high reproducibility, while eliminating errors due to coincidence losses, register losses, and detector aging effects.

High-Level Radiation

The United States Atomic Energy Commission has entered into a contract with the Emerson Radio and Phonograph Corporation of Jersey City, N.J., acting for the CEM Group, for a technical and management study of industrial applications of high-level radiation. The CEM (chemicals, electronics, metallurgy) group is composed of the Emerson Radio and Phonograph Corporation, General Aniline and Film Corporation of New York, and Revere Copper and Brass, Inc. of New York. The CEM study is an initial effort by the Commission to survey means of, and expected benefits from, an acceleration of the development of economic high-level radiation for industrial processing. The study, which is expected to be completed in about 10 months, includes a survey of world technology on current and foreseen uses of high-level sources of gamma radiation; a survey of United States industry's current and planned uses, on a commercial scale, of large gamma irradiators; and a comparison of the technical, economic, and management advantages and problems associated with potential applications of high-level radiation with advantages and problems of other energy sources or chemical agents which may be competitive.

Concrete Shielding

A publication by the American Concrete Institute, *Concrete for Radiation Shielding*, is a compilation of seven papers on the use of concrete for shielding nuclear radiation and the calculation of proportions and properties of various heavy concretes.

In Parliament

TEACHING MATHEMATICS

Much has been said and written about the urgent requirements for university graduates, for the teaching profession and for industry, and the small numbers available. It is certain that the subject will continue to demand attention until such time as there is a better balance between demand and supply. In the House of Commons last week, a brief adjournment debate took place on the question of granting deferment from national service to graduates with third-class honours in mathematics, in order that they might take up teaching posts.

This subject was selected for discussion by Mr. Eric Johnson (Conservative) who gave as his reason a wish to draw attention to the immense difficulty being experienced by the North Manchester Grammar School in securing teachers of mathematics. The school encountered that difficulty in spite of the fact that it had about 730 boys, was the only grammar school in north Manchester, and had a very fine record in open scholarships and in public examinations. It had a sixth form of 140 boys, of whom nearly 90 were studying science and mathematics. The school had a high reputation for teaching those two subjects and about one in five of the boys went from the school to a university.

For some reason or other, third-class honours graduates in physics and mathematics had to work out their national service. It seemed a rather strange arrangement that a man with an ordinary degree in science, which would often include mathematics as a main subject, had his national service indefinitely deferred, while a man with the higher standard of third-class honours in mathematics was not deferred. One of the consequences of this position was that teachers of the subject were almost unobtainable.

He was aware that the Minister of Labour and National Service had explained the need for the present deferment regulations by saying that there was a serious shortage of graduates with third-class honours or a pass degree in physics and mathematics in the Armed Forces, and that, obviously, there was a greater need in the Forces for teachers in these subjects than for teachers of chemistry and biology. It seemed open to doubt, however, whether the most efficient and economical use of teachers was to put some of them into uniform.

DEFERMENT OF GRADUATES

Speaking in support of the view that the deferment regulations should be reconsidered in favour of these third-class honours graduates, Mr. William Hannan (Labour) said that he was not too well acquainted with the degrees of English universities, but he did know that in Scotland graduates with third-class honours degrees were very highly regarded.

In Britain's present position, in relation to that of the United States and Soviet Russia, regarding the production of science graduates and teachers, and the emphasis which industry placed upon science, the importance of teaching scientific subjects in the schools was becoming increasingly pronounced. Many reports, such as that by Sir Edward Appleton, had been issued emphasing the need for teachers.

Replying for the Government, Mr. Richard Wood said that, during the short time he had been at the Ministry of Labour as Parliamentary Secretary, he had gathered that the question of the deferment of graduates was one which bothered quite a number of members.

To understand the present situation, it was necessary to consider the history of the deferment arrangements. The scheme for science and engineering graduates was originally introduced in 1949, in order to allow a few graduates of high calibre to be deferred for important work connected with the defence programme. There was pressure to extend the scheme as the years went by and, in 1953, indefinite deferment could be granted to any science or engineering graduate undertaking employment on research or development work on designated defence projects, including work connected with atomic energy. It was not until 1956 that the scheme had been first extended to civilian employment, when indefinite deferment was granted to science graduates, including graduates in mathematics, with first and second-class honours for approved teaching posts in secondary schools.

In 1957, in order to assist industry and to aid important work in other directions, it was arranged that indefinite deferment could be granted to graduates with first-class honours for any work which needed a degree in science or engineering. As a result of continued pressure by industry and the teaching profession two more concessions were made respecting graduates leaving universities in 1958. The first was that the scheme which allowed first-class honours men an almost free choice of employment, was extended to second-class honours men who had also taken a higher degree. The other concession was that men with third-class and pass degrees in chemistry or biology, as well as men with ordinary or general degrees in science, were allowed indefinite deferment for approved teaching posts.

FORCES' NEED OF SCIENTISTS

The whole crux of the deferment arrangements, Mr. Wood said, was the need which the Services had for graduates in physics and mathematics. Modern weapons had become exceedingly complex and the Services were doing their own research on a great many of them.

There was a need by the army for graduates for its Atomic Warfare Establishment and for the Royal Artillery Rocket Regiment. The Royal Air Force needed them for the establishment at Farnborough and for guided weapon project teams. Graduates were also required to teach regular soldiers the principles involved in the operation and maintenance of these complicated weapons. There were other Services needs and the number of graduates available to them was not really very great.

The reason for the discrimination between degrees in different subjects, such as physics and mathematics on the one hand, and chemistry and biology on the other, was the much greater need that existed in the Services for men with degrees in physics and mathematics. It was the duty of the Minister of Labour to try to balance the competing claims of all the varying interests. He quite understood the importance of increasing the number of teachers in science and mathematics, and was immensely conscious of the great difficulty which the schools were facing in trying to obtain them.

There had been relaxations in the deferment arrangements almost every year. The position would be reviewed by the Technical Personnel Committee of the Ministry of Labour in the autumn.

RESEARCH IN AERONAUTICS

Mr. John Eden (Conservative) asked for a statement regarding the inquiry being held into the future of the aircraft industry, and was told by Mr. Aubrey Jones, the Minister of Supply, that the inter-departmental committee recently set up to inquire into the future of aeronautical research and development, was now examining other aspects of the industry. As decisions were reached on the committee's recommendations, he would make appropriate statements. A study was being made of the feasibility of producing a supersonic civil-transport aircraft. Broadly speaking, it was considered that an economic civil transport could be produced. What was at issue was the kind of transport that would be the most economic and it would be his concern, Mr. Jones said, to ensure that the decisions were taken as quickly as possible. With regard to the volume of research, the broad level of expenditure would remain unchanged, although the division of the expenditure, as between civil and military requirements, might alter. As to another point raised by Mr. Eden, he believed that manned aircraft would certainly have a future.

FOREIGN FIRMS' BRITISH FACTORIES

A plea was made by Mrs. Jean Mann (Labour) for the simplification of the procedure whereby industrialists from the United States and other foreign countries have to apply for permission to establish factories and other industrial enterprises in the United Kingdom. She asked the President of the Board of Trade if he were aware of the criticisms which had been made regarding the efficiency of his department's arrangements and of the view that the Board's handling of American inquiries compared unfavourably with the practice in Belgium, Holland and West Germany.

Sir David Eccles said that this was a difficult and important problem. He had examined the present procedure and if he could find ways of simplifying it, he would, but the position was complicated. In addition to this country's foreign exchange control, there were the planning controls and the distribution-of-industry policy which an endeavour must be made to operate.

FBI Survey of Business Prospects

Attention was called by Mr. Roy Jenkins (Labour) to the recent survey conducted by the Federation of British Industries into the prospects of business now presented to firms in Britain. He felt that this report showed that the majority of firms in British industry had a substantial excess capacity at the present time, and he asked what measures the Chancellor of the Exchequer proposed to take to bring that capacity into use. Mr. Derick Heathcoat Amory replied that he had studied the report with interest and welcomed the Federation's initiative in conducting the investigation. Actions taken by the Government showed that they were very alert in ensuring that their policies were modified where necessary in the light of changing circumstances.

Extending Export Credits

Mr. Jo. Grimond (Liberal), drew attention to the temporary financial embarrassment of certain Commonwealth countries and urged that they should be granted longer credit facilities, to enable them to purchase British goods more freely. Mr. Heathcoat Amory said he thought that the situation was changing. He was keeping the position under constant review and would discuss it with the other countries concerned, and with the international monetary institutions.

Deliveries of Britannia Aircraft

The Minister of Supply was asked by Mr. F. J. Bellenger (Labour) about the progress being made with the delivery of Britannia aircraft for military purposes. Mr. Aubrey Jones said it was hoped to put these aircraft into service around the end of the present financial year, and to continue deliveries thereafter at the rate of one a month. Deliveries might be expected to be completed about 18 months from the end of this financial year.

Use for British Pavilion at Brussels

Reference was made by Lady Gammans (Conservative) to the success achieved by the British Pavilion at Brussels Exhibition and she asked the President of the Board of Trade if he would consider re-erecting it on some suitable site in London when the exhibition closed. Sir David Eccles said consideration would be given in due course as to whether some further use could be made of that building and its contents. It had been designed deliberately for a particular site and a particular occasion, and he was informed that it would be difficult to dismantle the pavilion and re-erect it elsewhere.

The Human Element

Envy or Emulation?

Sir Arthur fforde, chairman of the BBC, said recently when addressing the annual meeting of the London Council of Social Services that one of the problems of the time was the necessity to admit that everyone had the obligation to do a day's work. A second obligation, he thought, was that we should trouble ourselves less about comparing ourselves with our neighbours.

There will be more agreement over the first of these than over the second. There is wide agreement that not enough people see the need for putting their share into the national cake before it is cut up. So far as the second is concerned there is no doubt that envy is not a pretty vice. If envy takes the form of political expression leading to favouring a levelling down to the lowest instead of upwards to the highest it has nothing to commend it.

In one sense, however, a sense of emulation, to get away from the word "envy," has a certain merit in all forms of society—for all forms of society are to some extent acquisitive. If a desire to be as comfortably off as someone else can lead to greater effort and a greater willingness to work harder—and such was the Victorian idea, not to say is the American attitude—it has a good deal to recommend it. Under such circumstances emulation is not mean and in a naughty world it has a certain amount of merit.

Expanding Steel

The German steel industry is being obliged to shed a small amount of labour. Such well-known concerns as Mannesmann, Klockner and Krupps are dismissing a few hundred men. The reason for this is the decline in orders but there is not expected to be a large amount of unemployment. The Coal and Steel Community secretariat has said that in its opinion the worst of the setback of the Western European coal and steel industries was over.

The German pattern is however notably different from the one in this country where there have been declines in order books but little redundancy of labour as yet. The main reason is that the German steel boom was much more spectacular than the one in this country. The pace of progress in Germany has been impressive since 1948 when the Deutschemark was revalued and there must inevitably be a pause before the next bound forward.

The British steel industry has moved forward cautiously and labour has benefited from it. Progress has been orderly and the industry has refused to be rushed. The consequent strain was put on the balance of payments to import steel and the workers as a whole paid for the conservatism in a temporary setback in their standard of living. It is arguable which is the better way of paying for short-term dislocation.

Politics in the E.T.U.

The challenge to the Communist domination of the Electrical Trades Union leadership continues. Undeterred by their failure to break into the union executive last year, Mr. L. Cannon and Mr. W. T. Sullivan sought and won places in the E.T.U.'s delegation to this year's annual congress of the T.U.C. They fill two of the nine rank-and-file places for which elections were held recently. Mr. Sullivan came seventh in the poll, with 10,056 votes and Mr. Cannon eighth with 9,286 The voting was close and the first four places in the poll were won (by members of the executive) with votes ranging from 11,033 to 10,540.

At the recent election for a full-time official in the London area, Mr. Cannon received 2,856 votes, about 1,000 less than the successful candidate, Mr. T. J. A. Symms. The "rebels" have evidently some way to go before they can make their influence felt in the union's councils. Yet their progress has been substantial since the Hungarian revolt was crushed by Soviet tanks. Anti-Communism is beginning to pay, but the type of person making progress is unlikely to affect very much the militant rôle that has become the E.T.U.'s in trade union affairs.

Healthy Diagnosis

At the present time there is a good deal of discussion about the dangers of letting deflation go too far. Attention is drawn to the level of unemployment and the fact that there are over the country as a whole more men seeking work than there are vacancies to be filled. This state of affairs is apt to become crossed with another development, namely, the contraction of certain industries. In one sense the two are in no way connected.

The fact has to be faced that the price of a high rate of technological advancement such as is going on at present must be a contraction of some old industries and a release of labour. There is no other way to expand the young industries. The present time is notable for the number of industries which are becoming smaller when measured in terms of manpower. Each is contracting for a different reason, but technological change is at the back of most of it.

Thus there is need for fewer miners because at last output per head is increasing, thanks to a high rate of investment. In a similar way there is need of fewer men for the railways as technical change and improved management techniques take effect. Also in transport buses have passed their peak as the roads become more crowded with private cars. In cotton, there is serious contraction for all time as man-made fibres and mass-production techniques increasingly take over the market that once belonged to cotton textiles. All these temporarily may swell the total of unemployment but they are a healthy sign of a virile economy.

Clerical Salaries

How do office workers' wages compare with those of manual workers? Are they paid more in London than in Liverpool? To what extent is clerical work done by men as compared with women and how does their rate of pay compare? Have the increases in clerical salaries kept pace with other wage increases—and the higher cost of living?

These are some of the questions upon which a survey undertaken in England, Scotland and Wales for the Office Management Association, London, endeavours to provide information. The results of the survey have just been published in a report *Clerical Salaries Analysis* 1958, by Dr. O. G. Pickard, Office Management Association, London. (42s.)

Clerical workers account for about 10 per cent of the working population yet, apart from the known salary scales for various grades of clerical workers in the civil service, local government, nationalised industries and some other organisations such as the banks, there is little up-to-date information relating to the pattern of salaries paid to these workers throughout the country.

The surveys of clerical salaries undertaken by the Office Management Association are therefore of special interest (similar surveys were made in 1942, 1946, 1950, 1952, 1954 and 1956), especially as the present survey indicates general trends since 1956 up to March of this year. Special reference is made to those clerical workers employed in private commercial, industrial and professional offices.

The results of a statistical survey of this kind have to be considered bearing in mind the distribution of the sample taken, details of which are given in the report. Women clerks formed 64 per cent of the clerks in the sample—a figure which may be compared with 67 per cent for women clerks in corresponding industries in 1951. Since 1956 adult clerks have had salary increases ranging from 11 to 16 per cent, i.e. about twice the increase in the cost of living (7 per cent since 1956). Compared with the manual worker, whose wage rate increased by 11 per cent in the same period, the clerks did slightly better, although for male clerks this improvement was only after a decade in which they had lost ground to manual workers.

The trend towards equal pay for equal work by men and women clerks has not continued. The checking of this trend, which was noticeable between 1950 and 1954, seems to have persisted and there are indications that since 1954 the gap may have widened just a little.

The report provides evidence that London, on the whole, does not pay the best; higher wages generally were paid on Merseyside, West Midlands, Central Clydeside, Tyneside and South Wales.

Manpower on the Farm

The attraction of the town in an age of full employment has long since produced for the farmer the problem of accommodating his needs to a dwindling labour force. In part the need to spread men more thinly over the land has risen from increased mechanisation. One has stimulated the other. Farm equipment syndicates have long been in vogue. To-day there is the possibility that the same thing will have to be done with labour.

The process has indeed started. There are in some areas organisations which will contract to provide labour to do certain kinds of work for the farmer. Also the jobbing worker who has a particular skill or aptitude is increasingly going round farms offering his specialised services. The whole industry is clearly moving towards the organisation in varying degrees of pools of labour which can be voluntarily directed by some form of management to certain farms to do particular jobs.

The larger use of machines on the farm and the higher rates of pay which have to be accepted by the farmer are gradually forcing the industry to make better use of the available labour. This is the other side to higher output per worker.

Not Before Time

Old-age pensioners have at one fell swoop increased by 400,000 and the nation's liability by £50 million. This brings the total number of retirement pensions to nearly 5¼ million and the current total cost to some £630 million a year. This large new batch of qualifiers are those who became insured for a pension on or after 5 July, 1948—the date when the National Insurance Scheme came into full operation—and who on that date were men aged between 55 and 65, and women aged between 50 and 60. In official jargon—surprisingly expressive in this instance—they are known as late-age entrants but will draw standard rates of pension.

Late-age entrants' pensions are subject to the earnings rule while the pensioner is under 70 (man) or 65 (woman). Under this rule any earnings of more than 50*s*. a week reduce the following week's pension. The Government have been thoughtful about the new pensioners' comfort. Monday has been specially chosen as pay day for them, because the Post office "is not nearly so busy on that day." By cashing their pension orders on Mondays, pensioners will normally avoid queues and save themselves time. They have certainly not much time to spare after this 10 years' delay.

Research and Development

ORTHOGONAL CUTTING OF A WORK-HARDENING MATERIAL

Theoretical and Experimental Investigation

By D. G. Christopherson, O.B.E., Ph.D., P. L. B. Oxley, B.Sc., and W. B. Palmer, Ph.D.

In recent years the development of the mathematical theory of plasticity has progressed very rapidly. The concept of the rigid-plastic material has been successfully employed to provide theoretical solutions to a number of problems relating to metal-working processes, particularly in the field of rolling, drawing and extrusion, and in many cases the results obtained theoretically have been verified in all their main features and with very fair accuracy by direct experiment.

Accordingly, it is all the more disappointing that similar treatments have not been nearly so successful in accounting for what happens in continuous metal-cutting, as in a lathe. In the simplest case of orthogonal cutting in which the edge of the tool is perpendicular to the direction of motion, the problem can be regarded ideally as one of plane strain in two dimensions, provided that the width of the cut is large enough, and it is in just this class of problem that the theory of the slip-line field developed by Hill, Prager and others has been most successful. A number of attempts have been made to apply this theory to the cutting problem, the best known being those of Ernst and Merchant.[1] and of Lee and Shaffer.[2] The starting point of both these treatments is the same. (Indeed it is difficult to see what alternative is available when consideration is limited to the case of the ideal rigid-plastic material.) In both treatments, deformation is assumed to take place on a single plane, the "shear plane," as shown in Fig. 1, the inclination of which determines the ratio of the chip thickness T to the depth of cut *t*. The two theories differ in the method adopted for determining the position of the shear plane. Ernst and Merchant assumed that shear would occur on that plane which required the minimum expenditure of energy in cutting. Lee and Shaffer considered that over most of the range of possible rake angles, the decisive factor determining the inclination of the shear plane would be the conditions of plasticity in the material of the chip. Both hypotheses were, however, open to objections both on theoretical grounds and when tested against the results of experiment, for the following reasons.

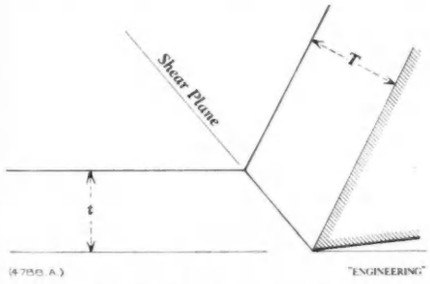


Fig. 1 Showing how inclination of shear plane determines ratio $\frac{T}{t}$.

(*a*) The shear plane inclinations found in practice $\left(\text{from measurements of the ratio } \frac{T}{t}\right)$ are for some rake angles substantially different from those predicted by either theory.

(*b*) Both theories predict that the chip when formed will be straight. In practice it is almost invariably curved, the curvature in many cases being large enough to suggest "bending" strains on the chip which are appreciable compared with the shear strain known to have occurred.

(*c*) According to Hill,[3] the shear plane inclinations predicted lead in many cases to stress conditions near the surfaces which cannot be satisfied. In addition there are fundamental reasons why the minimum energy principles which are so successful in the field of elasticity, may be misleading when applied in the plastic range.

Some attempts have been made to account for these anomalies by introducing additional physical considerations, such as the change in mechanical properties of the material due to heating on the shear plane. It appears, however, that this effect must necessarily depend a good deal on the speed of cutting, and would have little influence at very low cutting speeds. In practice, the discrepancies between theory and experiment at low speeds are at least as great as at higher speeds.

In view of these discrepancies, it seemed worth while to endeavour to make some direct observations of the process of deformation in metal-cutting. For our purpose it was not sufficient to predict the inclination of an assumed shear plane by measurements of chip thickness, since we were inclined to question the existence of a single shear plane. We proposed to observe not only the direction and magnitude of the tool force, and the dimensions of the chip for given cutting conditions, but also the deformation occurring in the plastic zone. Previously observations of this kind have been made by scribing a fine rectangular grid on the flat surfaces of two similar blocks, by clamping the two blocks together so that the scribed faces form the central plane, and then carrying out an orthogonal cutting process on one of the edges of the block thus formed. The operation can then be stopped at any stage, the blocks can be separated and the deformation of the rectangular grid in and near the cutting zone can be measured.

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This method has the great advantage that the true plane strain conditions can be maintained on the surface of observation. It has, however, some disadvantages. Observations can only be made when the cutting process has been stopped and the specimen unloaded. Additional deformations (or recovery of deformation) may occur in the unloading process. Moreover, it is difficult to provide a grid which is fine enough to record accurately the strains in a chip of the dimensions employed in practice. A "large-scale" model has often to be employed, and this may lead to difficulties due to scale effects. It therefore seemed of interest to adopt an alternative procedure which would accept the fact that what occurred in the field of observation was not perfectly plane strain, in order to be able to observe the cutting process continuously while it was actually going on, though at slow speed, with cutting conditions which (except for speed) were identical with what might be encountered in practice. This was done by photographing the cutting zone continuously with an ordinary ciné-camera through a microscope. The magnification was such that no inscribed grid was necessary, since the boundaries of the individual crystal grains could be clearly seen and their progress through the plastic zone could be observed. When the work began we foresaw two difficulties, first that insufficient illumination might be available on the field of view to provide an adequate exposure for the ciné-film in the time available, and secondly, that the deformation in the normal direction (non-plane strain) would be so large and the deformed surface in the chip so uneven, that adequate focus would not be maintained over the whole field of view. In practice, neither of these difficulties proved insuperable. We were able to obtain quite good photographs employing a magnification × 50 and illuminating the field with a standard type of 48 W 6 V bulb. With this arrangement, an exposure of $\frac{1}{1500}$th sec. at *f* 22 was found to be sufficient, and the aperture gave a satisfactory depth of focus.

The films thus obtained were projected frame by frame on to a screen and the track of a particular identified point in the material could thus be plotted at equal time intervals as it passed through the plastic zone from the work to the chip. (In many cases, deformation was so severe that particular crystal features might become unidentifiable at some stage; the complete track could then only be obtained in two or more sections derived from the observation of different points.) From the plot, of which a typical example is shown in Fig. 2, the magnitude and direction of the velocity of the material at any point in the plastic zone could be directly observed. No more than a cursory examination is required, however, to suggest the following conclusions.

(i) The deformation is not concentrated on a single shear plane but takes place more or less continuously* as the material moves through a plastic zone of roughly triangular shape with vertex near the point of the tool and base length on the free surface of the order of one-half to one-third of the chip thickness, as in Fig. 3.

(ii) Within this deformation zone the track of any particular particle is roughly a circular arc.

(iii) At no stage is the free surface of the chip straight. The inner surface in contact with the tool appears to be straight only over a short length, often at an appreciable distance from the tool point, where it is flattened by the elastic deformation caused by tool pressure. If cutting is stopped or the tool withdrawn, the chip has a

* It has, of course, often been remarked by writers on plasticity that where the theory of the rigid-plastic solid predicts discontinuous shear planes, in practice these are likely to be diffused over a band of finite width.

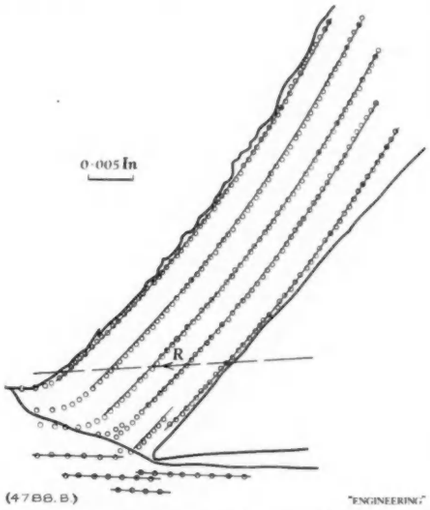

Fig. 2 Plot showing magnitude and direction of velocity of material in plastic zone.

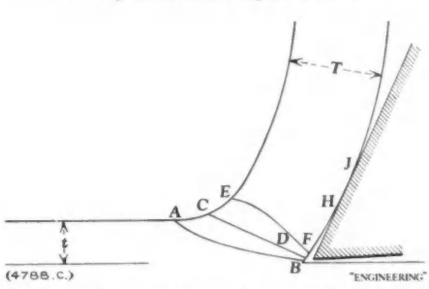

Fig. 3 Slip-line field in chip near point of tool.

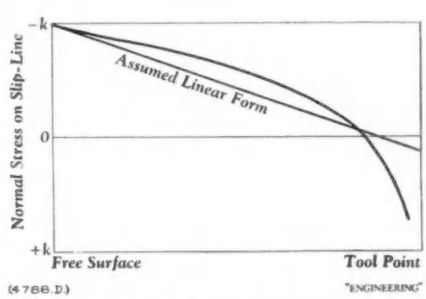

Fig. 4 Curve showing variation in hydrostatic stress.

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constant curvature from the boundary of the plastic zone.

It is not difficult to show that these observations are inconsistent with the assumption that the material behaves as an ideal plastic-rigid solid. The upper and lower boundaries of the plastic zone, for example, are slip-lines of the same family, and could not on that assumption have curvature of opposite signs, as they are observed to have. It therefore seems necessary to reject the ideal rigid-plastic hypothesis, and to adopt another more accurately representative of the real material. In what follows we shall endeavour to show that the observations can be explained if the material is treated as a work-hardening material, i.e., if the yield stress is allowed to vary as the strain progresses.† We shall, however, continue to assume that the material behaves isotropic-

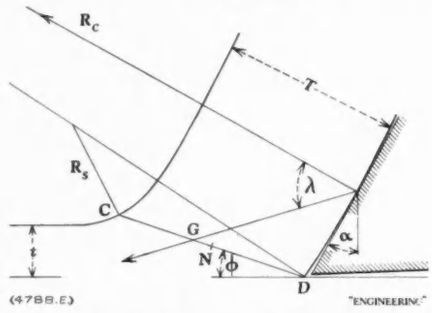

Fig. 5 Idealised diagram of cutting process.

ally, i.e., that even after it has been subjected to considerable shear strain in a given direction, it still has the same properties in all directions. Such a hypothesis is almost certainly untrue for large strains, but the theoretical difficulties inherent in any other treatment are too great to be faced at this stage, when the best that can be hoped for is a quite approximate treatment.

PLASTIC EQUATIONS FOR A WORK-HARDENING MATERIAL

The introduction of work-hardening modifies the basic theory of the rigid-plastic material in plane strain only in some particulars. The main outlines remain the same. A slip-line field, comprising two orthogonal sets of curves representing the directions of maximum shear stress and maximum shear strain-rate, must still exist. The condition that the material is incompressible (which can be retained) still requires that the rate of extension along any slip-line shall be zero. The stress system on any two perpendicular planes x, y is still expressible in terms of the hydrostatic tensile stress p, the shear stress on the slip-lines k and the inclination θ of the given planes to the slip-lines, by the equations

$$\left.\begin{aligned}\sigma_x &= p - k\sin 2\theta\\ \sigma_y &= p + k\sin 2\theta\\ \tau_{xy} &= k\cos 2\theta\end{aligned}\right\} \quad . \quad . \quad (1)$$

Hencky's statement of the equilibrium conditions, however, requires modification. The general equilibrium equations for plane strain are

$$\frac{\partial\sigma_x}{\partial x} + \frac{\partial\tau_{xy}}{\partial y} = 0\,;\quad \frac{\partial\sigma_y}{\partial y} + \frac{\partial\tau_{xy}}{\partial x} = 0. \quad . \quad (2)$$

Substituting from (1) in (2) we have

$$\left.\begin{aligned}&\frac{\partial p}{\partial x} - 2k\cos 2\theta\frac{\partial\theta}{\partial x} - \sin 2\theta\frac{\partial k}{\partial x}\\ &\qquad + \frac{\partial k}{\partial y}\cos 2\theta - 2k\sin 2\theta\frac{\partial\theta}{\partial y} = 0\\ &\frac{\partial p}{\partial y} + 2k\cos 2\theta\frac{\partial\theta}{\partial y} - \sin 2\theta\frac{\partial k}{\partial y}\\ &\qquad + \cos 2\theta\frac{\partial k}{\partial x} - 2k\sin 2\theta\frac{\partial\theta}{\partial x} = 0\end{aligned}\right\} \quad (3)$$

Suppose now we choose the axes x and y to coincide at a particular point with the directions of the slip-lines, so that $\theta = 0$. Then in place of (3) we have

$$\left.\begin{aligned}\frac{\partial p}{\partial x} - 2k\frac{\partial\theta}{\partial x} + \frac{\partial k}{\partial y} &= 0\\ \frac{\partial p}{\partial y} + 2k\frac{\partial\theta}{\partial y} + \frac{\partial k}{\partial x} &= 0\end{aligned}\right\} \quad . \quad . \quad (4)$$

† Of course, variations in yield stress for reasons other than work-hardening, for example those due to temperature or strain-rate, will produce similar effects.

Thus integrating along any slip-line

$$\left.\begin{aligned}p - 2k\theta + \int\frac{dk}{ds_1}ds_2 &= \text{constant}\\ p + 2k\theta + \int\frac{dk}{ds_2}ds_1 &= \text{constant}\end{aligned}\right\} \quad . \quad (5)$$

where ds_1, ds_2 are the elements of length measured along the two families of slip-lines. In the case of the ideal rigid-plastic material, k is constant everywhere in the plastic zone, so the last term in each equation vanishes, and Hencky's equations, in the usual form, are obtained.

It is perhaps worth while to interpolate at this stage a very rough estimate as to the importance of this "work-hardening" term in the equilibrium

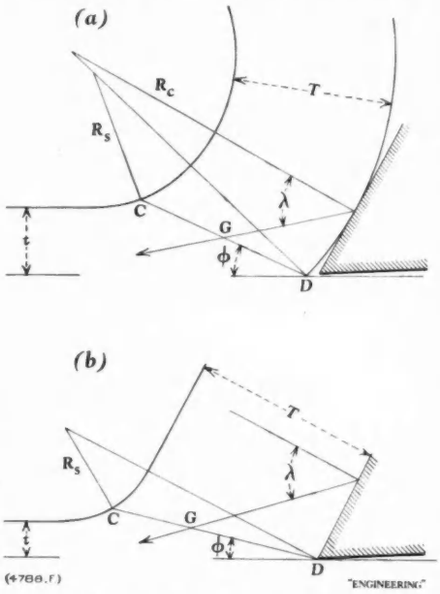

Fig. 6 Effect of angle ϕ on curling of chip.

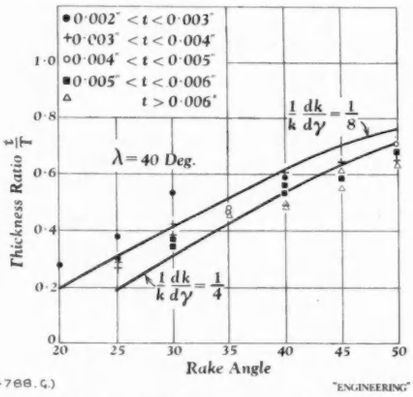

Fig. 7 Relationship between chip-thickness ratio and rake angle for $\lambda = 40°$.

equations. In a typical instance in which a mild steel is machined the yield stress in the chip k_c may be 40 per cent more than that k_{sr} in the parent material (in some cases the difference may be much greater). Employing a finite-difference approximation

$$\int\frac{dk}{ds_2}ds_1 \simeq \frac{(k_c - k_{sr})}{s_2}s_1$$

where s_2 is the length of a slip-line passing through the plastic zone in Fig. 3. The mean value of the ratio $\frac{s_1}{s_2}$ is of the order of five, and so the magnitude of the work-hardening terms in equations (5) is of the order of

$$5 \times 0{\cdot}4\,k = 2k \quad . \quad . \quad (6)$$

Now in the free surface, $\tau_{xy} = 0$, i.e., $\theta = 45°$ in equation (1); one of the principal stresses σ_y is also zero and thus $p = -k$. On a straight shear-plane θ does not change and thus, from equation (5), if work-hardening is neglected, $p = -k$, at all points from the free surface to the point of the tool. If the work-hardening term is taken into account, however, the hydrostatic stress along a straight slip-plane changes from compressive at the free surface by the amount estimated in equation (6) to something of the order of $p = +k$ (tensile) near the tool point. If the plastic zone is in fact narrower than is envisaged in Fig. 3, the work-hardening term becomes still more important, and larger hydrostatic tensile stresses must be envisaged. It seems therefore that any theory which neglects this effect is bound to lead to stress distributions which are seriously misleading when applied to the cutting of most real materials.

APPROXIMATE THEORY FOR ORTHOGONAL CUTTING

A complete theoretical solution of the problem of cutting for a work-hardening material based on equation (5) appears to be a matter of great difficulty. In what follows, we attempt to build up a semi-empirical and partial theory, which though quite incomplete, may be of some value in indicating in a roughly quantitative way the relations between the main quantities required. It should be made clear that this is only one of several possibilities by which approximate treatments can be developed. It has the advantage of mathematical simplicity, but it will be seen that it can be applied only to a limited range of conditions.

Some simplifying assumptions are plainly necessary. Referring again to the slip-line field sketched in Fig. 3, it can be assumed that the material when it reaches the first slip-line A B is in a uniform condition. There is also some evidence from the plots that the strain on any slip-line C D, E F is fairly uniform. Accordingly, it seems reasonable to assume that along any slip-line of the same family as A B, C D, there is no variation in yield stress.

Some further information about the nature of the slip-line field can also be obtained from our photographic records. If the streamlines could be determined with sufficient accuracy, the complete slip-line field could be deduced directly by making use of the condition that there is no change in velocity along a slip-line. The accuracy achieved by our technique is only sufficient, however, to give a rather rough indication of the form of the slip-line field. It also appears that there are fundamental difficulties in meeting both the stress conditions and the velocity conditions without discontinuities particularly in the region E, Fig. 3. However, it appears that provided that the rake angle is not too small, one straight or nearly straight slip-line as at C D does appear, and this line can conveniently be used for calculations of tool force, etc., provided that the work-hardening term $\frac{dk}{ds_2}$ can be estimated at all points along its length.

The spacing of the slip-lines indicates that $\frac{dk}{ds_2}$ decreases slightly at the free surface, but increases rapidly again as the tool point is approached. Accordingly the variation in the hydrostatic stress as given by equation (5) with θ constant must be as sketched in the curve in Fig. 4, and approximate estimates of the resultant normal force across the streamline can be obtained by treating $\frac{dk}{ds_2}$ as constant at the value which obtains at the free surface. This value is easily calculated, if the radius of curvature R_s of the surface is known. Since the slip-lines meet the surface everywhere at 45°, and it is assumed that deformation is in the main a slide along planes A B, C D, the shear strain γ at the point where the free surface has turned through angle β is approximately $\sqrt{2}\,\beta$. Then

$$R_s\,d\beta \simeq \sqrt{2}\,ds_2$$

and

$$R_s\,d\gamma \simeq 2\,ds_2$$

and

$$\frac{dk}{ds_2} \simeq \frac{2}{R_s}\frac{dk}{d\gamma} \quad . \quad . \quad . \quad (7)$$

The gradient $\frac{dk}{d\gamma}$ is of course a fundamental property of the material being cut, and is zero for the ideal rigid-plastic material.

Now across the straight slip-line C D of length l, the shear stress is constant, so that the total shear is kl. If it is assumed that the straight line C D terminates in the ordinary way at the free surface at a point where its curvature is continuous, then at this point $p = -k$ in accordance with the normal rule, and anywhere along C D the normal stress is given by

$$p = -k + \int_0^s\frac{2}{R_s}\frac{dk}{d\gamma}ds = -k + \frac{2}{R_s}\frac{dk}{d\gamma}s \quad (8)$$

An alternative approach to the problem is to discard the condition $p = -k$ at the point C, implying that a discontinuity in the surface exists at this point. In this event, it might be better to base force calculations on the boundary A B of the plastic zone. However, from equation (8) we have for the total force normal to C D

$$-k\,l + \frac{1}{R_s}\,\frac{dk}{d\gamma}\,l^2$$

and the resultant makes angle $\tan^{-1}\left(1 - \frac{l}{k\,R_s}\,\frac{dk}{d\gamma}\right)$ with C D. If, in the usual notation α is the rake angle of the tool, λ is the angle of friction between tool and chip, and ϕ is the inclination to the horizontal of the straight slip-line, we have

$$\tan(\phi + \lambda - \alpha) \doteq 1 - \frac{l}{R_s\,k}\,\frac{dk}{d\gamma} \quad . \quad (9)$$

or

$$\frac{R_s}{l} = \frac{1}{k}\,\frac{dk}{d\gamma}\,\frac{1}{1 - \tan(\phi + \lambda - \alpha)} \quad . \quad (10)$$

The line of action of the resultant can be easily deduced. It passes through a point G on C D such that

$$C\,G = \tfrac{2}{3}\,l - \tfrac{1}{6}\,l\cot(\phi + \lambda - \alpha) \quad . \quad (11)$$

An idealised diagram of the cutting process for any assumed value of α, λ and ϕ can now be constructed as in Fig. 5. R_s is calculated from (10). The final radius of curvature of the chip R_c is obtained from the fact that the line of action of the resultant force obtained from (11) must pass through the centre of the pressure area between tool and chip. For this purpose the elastic flattening of the chip must be taken as small.

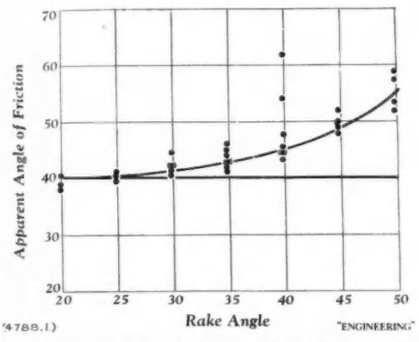

Fig. 8 Relationship between chip-thickness ratio and rake angle for $\lambda = 30°$.

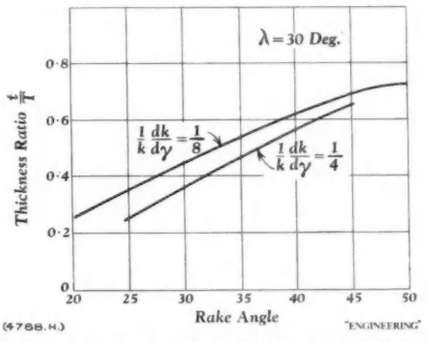

Fig. 9 Apparent angle of friction at different rake angles.

It follows from the hypothesis that the chip is curled from its inception, that the pressure zone between tool and chip does not extend as far as the tip of the tool so that the portion D H in Fig. 3 is left free of stress. It is, of course, frequently observed that the most severe tool wear takes place in the area H J. In many cases, though not often at the slow speeds employed by us, the space round the tool point is filled by the " built-up edge " formed by the detritus adhering to the tool. After such a built-up edge has been formed, a different stress distribution is no doubt to be expected.

So far, nothing has been said which touches on the essential difficulty of the existing theories of cutting—the determination of the angle ϕ. A diagram similar to Fig. 5 can be constructed for a number of values of ϕ for each value of $(\lambda - \alpha)$. A qualitative—but not as yet quantitative—argument for choosing ϕ can now be discerned. If the value of ϕ chosen is too large, as in Fig. 6(*a*), it will be found that a very tightly curled chip is required to satisfy the geometrical conditions, but the bending moment in the plastic zone, represented by the distance GN (Fig. 5), between the line of action of the resultant and the centre of the chip, is very small. On the other hand, if ϕ is too small, Fig. 6(*b*), very little or no chip curvature is required, but the bending moment is somewhat larger. It is suggested that the actual value of ϕ is that in which the bending moment in the plastic zone is just sufficient to produce the required chip curvature. No convenient means of relating the chip curl theoretically to the position of the resultant seems to be available; we can, however, proceed semi-empirically again by making use of the observed values of the chip curvature. In our experiments, the radius of curvature of the chip was in almost all cases in the range 4 to 10 T, where T is the chip thickness. By assuming an average value 5 T,* we can deduce the required values of ϕ and hence the chip thickness ratio $\frac{t}{T}$. This can be compared with the observed chip thickness ratio, and provides a general check on the ideas put forward.

The necessary calculations of $\frac{t}{T}$ have been performed for a range of values of the rake angle α and for two values $\lambda = 30°$ and $\lambda = 40°$ of the angle of friction, and these are presented in Figs. 7 and 8 and Table I.

COMPARISON WITH EXPERIMENTAL RESULTS

The coefficients of friction in the experiments as obtained by direct measurement of tool force are shown in Fig. 9. For small rake angles, the observed angle of friction is about 40° and this increases with rake angle at first quite slowly but when the rake angle exceeds about 45° very rapidly indeed, and to values which are unlikely on general grounds. We consider that these large apparent friction coefficients are illusory and are due to forces acting not on the face of the tool but on its flank. Accordingly, it seems to us that the best plan for the present purpose is to assume a constant coefficient of friction equal to that which obtains at small rake angles.

* It should be noticed that a large change in the chip curvature makes only a small change in ϕ.

Calculations have been made for two different degrees of work-hardening $\left(\frac{1}{k}\,\frac{dk}{d\gamma} = \frac{1}{8}\right.$ and $\left.\frac{1}{k}\,\frac{dk}{d\gamma} = \frac{1}{4}\right)$. Comparison with a compression test suggests that the latter is a better representation of the behaviour of the material employed over the relevant strain range. It will be noticed that in all cases a very thin cut tends to produce a proportionately thinner chip. The most probable explanation of this tendency seems to be that near the original surface of the material previous machining operations have caused some hardening. Thus the work-hardening coefficient is less than that of the bulk material, and as the diagram shows, a low work-hardening coefficient tends to produce a proportionately thinner chip.

TABLE I.—*Chip-Thickness Ratios* $\frac{t}{T}$.

	$\lambda = 30$ deg.		$\lambda = 40$ deg.	
$\frac{1}{k}\,\frac{dk}{d\gamma}$	0·125	0·250	0·125	0·250
$\phi + \lambda - \alpha$	33·8 deg.	29·35 deg.	25·9 deg.	21·4 deg.
$\alpha = 20$ deg.	0·260	—	0·198	—
25 ,,	0·356	0·256	0·310	0·190
30 ,,	0·445	0·364	0·410	0·308
35 ,,	0·535	0·455	0·510	0·422
40 ,,	0·619	0·563	0·610	0·527
45 ,,	0·695	0·650	0·695	0·626
50 ,,	—*	—	0·754	0·710

* Specified chip curvature cannot be achieved. A straighter chip is to be expected.

When this tendency is taken into account, reasonable agreement between the observed and predicted thickness ratios is obtained for rake angles greater than 25°. In one respect, however, the theory is unsatisfactory in that the predicted position of the resultant tool force as shown in Fig. 6 does not accord with the position which can be deduced directly from the photographic plots. The centre of curvature of the chip can be fixed by fitting arcs of circles to the trajectories shown in Fig. 2, since if a radius through the centre normal to the tool face is constructed, it presumably passes through the centre of the area of pressure between chip and tool The position of the resultant force R can thus be deduced, and it will be seen that in Fig. 2, a typical case, it passes altogether outside the cross-section corresponding to C D, whereas according to the above theory it should pass not very far from the centre of this cross-section. This suggests that the Hencky condition p = constant along the straight slip-line is even farther from the truth than would be supposed on a basis of the assumptions employed here. The theory also fails for small or negative-rake angles. It appears that the assumption of a straight slip-line terminating opposite the tool point is no longer a useful one under these conditions.

Some further reference must be made to conditions in the region of the tool point. It will have been observed that the ideas outlined above imply that a blunt tool will be as effective in cutting as a sharp one. This conclusion, on the face of it somewhat startling, can be shown to be true in some circumstances. If there is a built-up edge, for example, it is plain that the shape of the tool near its tip is without effect. The general nature of the deformation shown in Fig. 10 suggests that what is happening round the tool point is a stretching of the material rather than a cutting in the strict sense, and that the deformation is consistent with a local slip-line field of the kind shown in Fig. 11, in which the cross-hatched sections show the distortion of an initially rectangular grid. The effect of the sharpness of the tool may, however, be important in another way. We have all the time assumed continuous cutting conditions, without referring to what happens in the initial period before these conditions are established. Perhaps over part at least of the range steady conditions can never be achieved unless the tool is adequately sharp to begin with.

Finally, it is perhaps of importance to point out how these experiments may be expected to differ from practical conditions of cutting at much higher speeds.

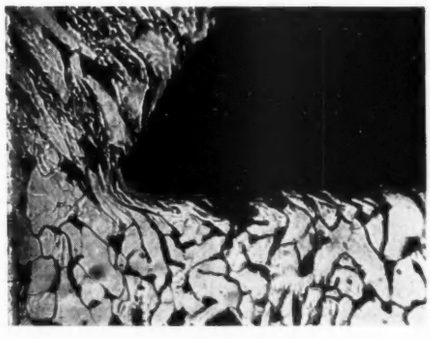

Fig. 10 Deformation of metal crystals near tool point.

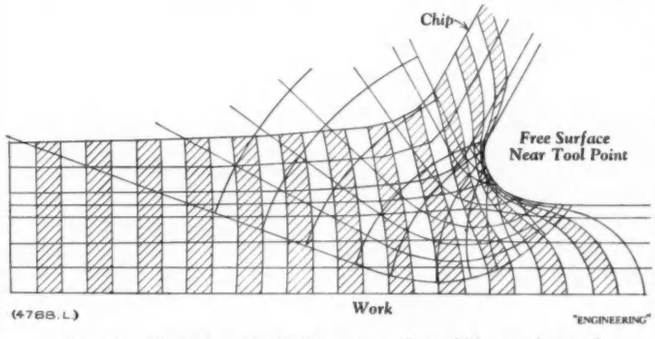

Fig. 11 Distortion of initially rectangular grid by cutting tool.

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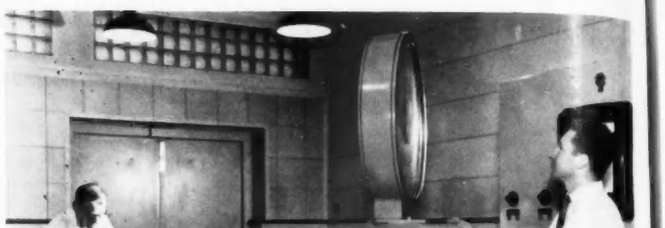
DYNAMOMETER *for Petroleum Research*

Fig. 1 (right) English Electric swinging-frame electric dynamometer at Esso Research Limited.

Fig. 2 (left) Characteristics of the dynamometer.



THE quality of fuels and lubricants for internal combustion engines can only be improved by operational experience. For this and similar reasons, every progressive oil company is continually testing fuels and lubricants in representative full-scale equipment. To accommodate the expanding scope of the work of Esso Research Limited at their laboratories near Abingdon in Berkshire, new buildings of advanced design have recently been completed. Among the test cubicles in the new engine laboratory is one equipped with an English Electric swinging-frame dynamometer, already in use for measuring the output horsepower and for motoring engines under test.

The equipment consists of the swinging-frame dynamometer, an a.c. mains-connected motor-generator set for absorbing the electrical power output of the dynamometer and supplying a variable d.c. voltage for motoring the dynamometer, and in addition, interlocked and protected push-button controls for the complete electrical circuit.

The dynamometer is a d.c. machine developed from the English Electric traction motor with an armature suitably constructed for high-speed operation. The machine frame is mounted on trunnion bearings to allow free rotation through a limited arc, and a torque arm is solidly connected by one end to the machine frame and by the other end to an Avery dial-reading and gravity-controlled weighing gear. In this way the horsepower transmitted by the armature shaft can be calculated from the load on the torque arm. A checking knife-edge mounted on the machine frame opposite to the torque arm allows the weighing gear to be calibrated by the direct addition of weights.

The duty of the dynamometer is two-fold: " absorption " and " motoring." When acting as a load for the test engine, it is capable of absorbing up to 150 h.p. at a maximum speed of 5,000 r.p.m., or alternatively 175 h.p. at 3,000 r.p.m. for one hour. When motoring to drive an inert test engine for hot friction tests, etc., the dynamometer and d.c. supply system are capable of providing about 60 per cent of the absorption ratings. Fig. 2 shows the absorption and motoring characteristics for the continuous maximum and one hour ratings.

The motor-generator set provides an electrical load during absorption duties, and supplies a variable voltage source for the dynamometer when motoring. It consists of an a.c. slipring induction motor/generator, a d.c. generator/motor and a constant voltage exciter, all directly coupled together on a combined bedplate. When the dynamometer is required for motoring duty, the a.c. motor drives the d.c. machine as a generator, whose output can be governed manually by excitation control, thus providing a variable voltage d.c. supply for the dynamometer. When the dynamometer is providing a load for the test engine, the dynamometer output is fed into the d.c. machine, which then operates as a motor, driving the a.c. machine as an induction generator. The a.c. output of the induction machine is fed back into the a.c. supply system, which thus absorbs the energy produced by the test engine.

Mechanical design of the dynamometer incorporates features which reduce torque losses due to restriction of frame movement. For example, the electrical connections to the machine are brought out from the underside of the frame in the form of flexible leads. Similarly, precautions have been taken to ensure that the forced ventilation air-ducting for the machine does not impede the rotational movement of the frame; cold air from outside the building is forced through a sheet-steel duct by a fan beneath the test-cell floor, and the forced air then enters the machine air circuit through a clearance entry. To eliminate any damage to the trunnion bearings due to test engine vibration, the outer races are rotated manually at regular intervals.

The controls, on a desk in the test cubicle include push buttons marked " control on," " main on," " control/main off," " increase load/decrease speed," " decrease load/increase speed " and " emergency stop." Also provided are ammeters and voltmeters, and indicating lamps for " main circuit closed," " paralleling fault," " control available," and so on.

A reduction bevel gear driven by the dynamometer armature shaft drives an electrical tachometer and a centrifugal overspeed device that can be set to cut off the ignition and fuel supply to the test engine in the event of dangerous overspeeding. Other relays and control circuits operate to protect the auxiliary equipment.

The main purpose of the dynamometer in this installation is the measurement of power loss, air pumping and viscous drag in internal combustion engines. Although more accurate methods of determining friction losses are known (e.g., electronic integration of power output curves), the accuracy of the more conventional types of torque measuring equipments is quite sufficient in this instance. In addition to providing sensitive measurement of engine torque over a wide range of power and speed, the swinging-frame electrical dynamometer has other important advantages. It can be used as a motor for driving the engine under non-firing conditions, and can change over instantaneously from absorption to load duty and back again as required. This latter capability enables the research engineer to determine the friction and pumping losses of the test engine under any conditions of engine operation and before the engine cools off or conditions change in any way. These losses can also be accurately estimated when experimental lubricants are being tested by successively removing the various engine components—head, piston rings and so on down to the bare crankshaft—while the dynamometer continues to provide the power.

In research work of this kind accurate measurement of fuel consumption is essential and this is achieved by using a fuel weighing device developed by Esso Research. The pressing of a single button results in the measurement of both rate of fuel flow and engine speed.

Apparatus of this type assists the petroleum technologist in keeping in step with changes introduced by the automobile engineer. Able quickly to determine quantitatively the improvements in performance due to fuel and lubricant quality changes, he continues his search for future improvements in efficiency.

Continuing Orthogonal Cutting

It seems likely that the difference will be of three kinds. In the first place, the angle of friction λ is likely to be smaller at high speed so that Fig. 7 is likely to be a closer representation of conditions than Fig. 8. Secondly, at high strain-rates the stress-strain curve of the material will be substantially altered; the initial yield stress will be very much enhanced, and the stress corresponding to large strains raised to a less extent. The stress-strain curve tends therefore to become more horizontal, and so the work-hardening coefficient as defined in this article becomes smaller. For these reasons it is to be expected that at high speed generally thinner chips will be produced.

An effect which may in some conditions be predominant has already been referred to. For a material having a relatively high yield point, cut at high speed and with small or negative-rake angle, the rise in temperature due to plastic work may be so large that the mechanical properties of the material are completely changed. In certain cases, some melting of the material may even take place, and neither the experimental method nor the theoretical considerations employed here are relevant. If, however, a clearer picture of the mechanisms at work in slow speed cutting can be obtained, it may be possible to discern some fresh lines on which the problem of high speed cutting can be investigated.

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[3] Hill, R. *Jour. Mech. and Phys. of Solids*, vol. 3, No. 1, page 47, 1954.

BRITTLE-FRACTURE INVESTIGATIONS IN SWEDEN

By C. Schaub

Head of Research Laboratory, Fagersta Steelworks, Sweden

IN RECENT years two methods have been developed in Sweden for determining the nominal tensile stress necessary for the propagation of a brittle fracture in steel plates or flat steel bars. They are based on the principle of subjecting the material to a pure tensile stress in the presence of increasing cracks, either fatigue cracks[1] or spontaneous cracks in a brittle surface layer welded on to the edges of the specimen.[2] Both methods give results of the type shown in the diagram, Fig. 1.

The yield strength, it will be seen, increases with falling temperature, whereas the brittle fracture strength decreases as the temperature is reduced. The curves intersect at a certain transition temperature T_c, which means that fracture is preceded by a general plastic deformation at temperatures above T_c, but not at temperatures below T_c.

The investigations also show that the value of T_c is higher for a heavy rolled plate than for a thin plate of the same material. This is due to two effects: one, metallurgical (larger grain size or coarser structure in the heavier plate owing to higher final rolling temperature and slower cooling rate after rolling, etc.); the other purely geometrical. The latter effects result from the dynamics of brittle-fracture propagation in the specimen. The conditions encountered are shown diagrammatically in Fig. 2. Plates of all thicknesses were hot rolled from the same charge. The curves in Fig. 2 show the critical transition temperatures for 12 mm. and 20 mm. plates.

If, however, the thickness of the 20 mm. plate is reduced to 12 mm., say by planing, the corresponding curve of brittle fracture strength and the critical transition temperature will be moved as shown.

The Swedish investigations show that the difference between the transition temperature for the rolled 20 mm. plate and that for planed-down plates is equal to the geometrical effect and is greater than the metallurgical effect, which is the difference between the transition temperature for the planed-down plate and that for the 12 mm. rolled plate.

The results recorded above have considerable practical significance as follows:

(1) As the thickness of the plate increases, the structure and nature of the material have progressively less effect on the tendency to brittle fracture.

(2) Notch ductility tests, such as the Charpy V-notch test, on specimens of standardised dimensions taken from plates of the same material of increasing thickness become progressively less severe.

(3) The results of notch ductility tests of the standard Charpy type do not give the right order of merit when materials in the form of plates of widely different thicknesses are investigated.

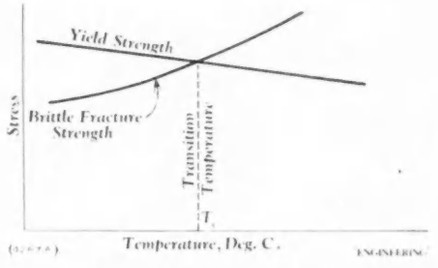

Fig. 1 Showing brittle fracture strength and yield strength as functions of temperature.

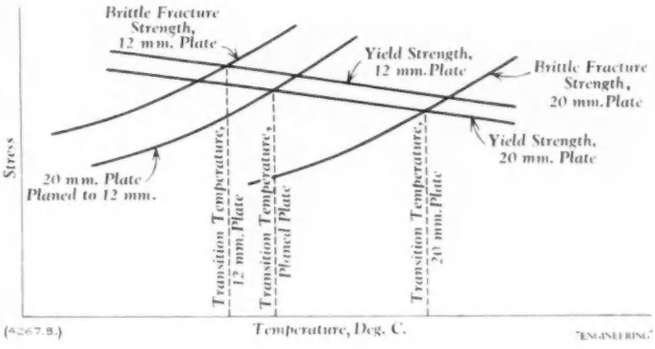
Brittle Fracture Strength, 12 mm. Plate
Yield Strength, 12 mm. Plate
Brittle Fracture Strength, 20 mm. Plate
Yield Strength, 20 mm. Plate
20 mm. Plate Planed to 12 mm.
Stress
Transition Temperature, 12 mm. Plate
Transition Temperature, Planed Plate
Transition Temperature, 20 mm. Plate
Temperature, Deg. C.

Fig. 2 Brittle fracture strength and transition temperatures for plates of various thicknesses.

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[2] T. Norén, *Jernkontorets Annaler*, No. 3, pages 141 to 153, 1955.

ELECTRON BEAM MELTING AND PURIFICATION

A process using electron bombardment in a high vacuum to melt chemically-active materials which have high melting points has recently been announced jointly by Stauffer Chemical Company, Mallory-Sharon Metals Corporation, and Temescal Metallurgical Corporation. The process enables the melting and casting of special metals such as titanium, zirconium, tantalum, molybdenum, and columbium to be carried out; and it is owned by the three companies, which have co-operated in its development and proved it on a semi-works scale. Techniques have been developed that make possible the volatilisation and removal of certain critical impurities. The semi-works plant has successfully melted, purified, and cast a dozen special metals in water-cooled crucibles, with no contamination from the crucible.

The companies say that the economics of electron bombardment melting appear favourable, in the present stage of development, because high-voltage direct-current electrons are relatively cheap and power efficiencies are high. The purification of columbium requires 3 to 4 kWh per lb, while tantalum requires about 6 to 8 kWh per lb. By comparison, the solid state sintering of tantalum uses 500 kWh per lb. Moreover, the economic factor is not the only one showing an advantage; it appears that tantalum, molybdenum, and other metals have been produced at higher purities than has been usual before. Ductile columbium, previously only a laboratory curiosity, made by solid-state sintering, is now commercially possible. One industrial customer has made 0·5 mil columbium foil from a 3 in ingot by cold rolling—an achievement only made possible by the high-purity ingot produced by electron-bombardment melting.

The process, conceived by Temescal, is based primarily on high-vacuum techniques. Heat for melting is supplied by an electron gun that serves as the cathode and bombards the metal stock (the anode) with electrons, heating it to melting point. Molten metal drops into a water-cooled copper crucible below, in which the heat required to maintain a molten pool is also provided by electron bombardment. As the solidified ingot is withdrawn downward the molten pool surface is maintained at a constant level.

The process differs from vacuum arc melting not only in the heating mechanism but also in the level of vacuum used—the range 0·01 to 0·1 microns, rather than 10 to 100 microns. Under the conditions existing in the furnace, carbon, hydrogen, and oxygen are generally removed rapidly as carbon monoxide, metal oxides, or similar compounds and, as a rule, impurities which form compounds having a vapour pressure of at least 10^{-5} atmosphere at the surface of the melt can be removed easily.

Electron beam melting should offer several advantages over vacuum arc melting. For example, electron beam operations can be stopped and started at any time, whereas arc melting cannot. In the latter process a valuable ingot is often lost if it becomes necessary to halt the process. In addition, the electron beam can melt material in any form, for example, ingot, powder, flake, or sponge, whereas the arc process requires compacted material.

The process can be used for zone refining. In some respects, it may prove superior to present zone-refining processes. One advantage is that there is no apparent limitation on the diameter of the bar or ingot that can be processed, as there is for highly-reactive metals in conventional zone-refining operations. The companies claim that electron beam melted materials can thus be purified more speedily and cheaply.

The joint venture plans to license the process to interested industrial and research concerns. Information on the process may be obtained from Dr. Charles Hunt, joint venture melting project manager, Temescal Metallurgical Corporation, 1415 South 47th Street, Richmond, California, U.S.A. As part of the licensing programme the joint venture will: fabricate and supply furnaces and accessory equipment; make available its accumulated process experience; train the personnel of licensees; and supply technical information continuously to licensees.

RECORDING ROAD PROFILES

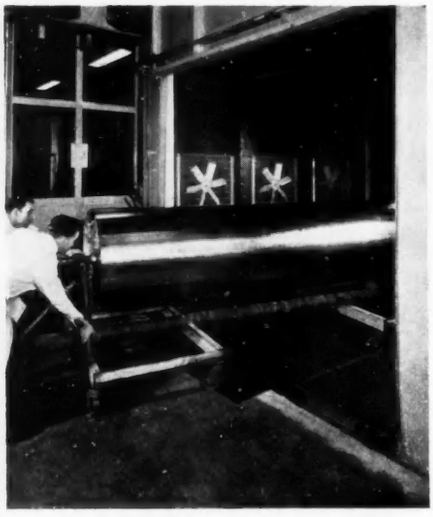
A specially-designed 22-wheel motor-vehicle recently began a survey of the surfaces and profiles of 9,300 miles of highway in the State of Michigan. The work is being carried out, through the University of Michigan, under a 45,000 dol grant from the Michigan Trucking Association, the American Trucking Associations, and the Automobile Manufacturers Association. The vehicle is provided with 16 small wheels at the front and rear, and these, together with recording wheels in the centre, are used to record the profile of every mile of road, the total surface irregularities per mile, and the difference in elevation between the wheel tracks. Michigan is the second state in the United States to develop such a vehicle. California has a similar one.

The instruments on the vehicle are situated in a second cab, which is directly behind and above the driver's compartment, and the two are linked by an "intercom." At the rear of the vehicle are situated the crew's quarters. Moving from 4 to 5 m.p.h., the vehicle can detect road irregularities as small as $\frac{1}{32}$ in. Data are recorded on graphs, which will be used to show the effect of variations in soil conditions, drainage, and construction, as modified by local weather conditions. A camera mounted at the rear of the vehicle photographs each road slab to enable progressive changes, if any, in the crack patterns to be detected. The vehicle also has an arrangement of targets and mirrors to help the driver to remain parallel with the kerb.

Metals and Materials

DISPERSION COATINGS OF PTFE

Facilities for the application of dispersion coatings of polytetrafluoroethylene (PTFE) to a wide variety of articles are now available at the Tottenham factory of Siemens Edison Swan Limited, 155 Charing Cross Road, London, W.C.2.



A large roller used in the textile industry, supported on a trolley, being wheeled into an oven to receive a dispersion coating of PTFE.

In addition to excellent electrical characteristics and heat and corrosion resistance, a dispersion coating on an article renders its surface completely inert and "non-sticking" with an almost zero coefficient of friction. At present rollers, moulds, hoppers and other articles employed in the textile, paper-making, bakery, confectionery, plastics and chemical industries are being coated, and new applications of the process are continually making their appearance.

At the Siemens Edison Swan Tottenham factory, the PTFE coating can be applied to articles of almost any size and newly-installed plant includes ovens capable of accepting parts considerably larger than a motor car. Moreover, conveyor ovens will handle quantities of small parts.

The thickness of the dispersion coating varies according to the needs of the article coated, but usually ranges from about 0·0005 in to 0·004 in. We are informed that coatings of this order of thickness stand up to wear remarkably well and it is added that although PTFE is still comparatively expensive, the thin deposit which is adequate for most normal purposes renders the treatment of quite large articles an economic proposition.

LEAD AND ITS MANY APPLICATIONS

The principal objects of the Lead Development Association, as might be expected from its name, are to extend knowledge on lead and its manifold uses and to foster the appreciation of its merits.

The Association is an advisory non-profit earning body which was formed in 1954 by the leading Commonwealth producers of lead, and, in 1957, the affairs of the Lead Sheet and Pipe Council operating under the aegis of the Lead Sheet and Pipe Manufacturers' Federation, were integrated with those of the Association.

The L.D.A., as it is usually called, is a subscribing member of the British Non-Ferrous Metals Research Association and has co-operated with that body and with several technical colleges in a number of researches. A close liaison is maintained with the Lead Industries Association, of New York, and with similar associations in the Commonwealth and on the Continent. *Lead News*, *Applications of Lead*, and other periodicals and publications are issued at intervals and the Association takes a special interest in the education of student technicians and supplies schools with wall charts, booklets and other material.

In view of the expanding activities of the Association larger office accommodation had become necessary and a suite of offices, in the auxiliary building of the Royal Society of Arts, at 18 Adam Street, London, W.C.2, were acquired in October, 1957, and were inspected during "Open Days," held from July 7 to 11, by Government and Commonwealth officials, trade representatives and other interested visitors. The accommodation embodies a large room which is used as a Council chamber and, alternatively, as a venue for displays and lectures. The arrangements also include provision for the projection of films and space has been allocated for a library.

TERYLENE WEBBING PIPE STRAPS

In the modern factory of the Bowaters Paper Corporation, at Ellesmere Port, Wirral, Cheshire, Terylene webbing straps are employed for the suspension of slack pipes carrying a mixture of paper pulp and water.

Some 2,000 of these straps, supplied by "W" Ribbons Limited, 12 Commerce Way, Purley Way, Croydon, Surrey, are used and the average length of each strap is about 4 ft. Their width is 2 in and their breaking strength 10,000 lb.

The advantages claimed for the Terylene webbing straps are that they are more manageable and less expensive than metal supports and, furthermore, that they have a higher resistance to acids, moisture and abrasion than natural-fibre webbing.

Terylene is the name given to the synthetic polyester fibre produced by Imperial Chemical Industries Limited, Fibres Division, Hookstone Road, Harrogate, Yorkshire. The material is also used for making ropes, hoses, belting and cloth.

NON-STICK BACKING PAPER

A range of backing and inter-leaving papers coated with special silicone and plastics finishes to provide any required degree of resistance to adhesives is now being produced by the RWP Company, Fishponds, Bristol, an associate of the Robinson Group. They are being marketed under the name of "Striplac," and are designed for the protection of all types of adhesive-coated or "sticky" commodities, such as surgical dressings or uncured rubber, whether it be in handling, storage, or retail packaging.

The "Striplac" range can be supplied in various strengths and types of paper, printed in up to six colours with overall designs incorporating the product's brand name, instructions for use, or other advertising matter. The low initial cost allows the papers to be completely expendable after use, in contrast to conventional cloth backings. Types are available which will not adhere at all, or which will adhere lightly so that the adhesive is not damaged when the backing is stripped off.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Bell Furnaces. G.W.B. FURNACES LTD., P.O. Box. No. 4, Dibdale Works, Dudley, Worcestershire. Electric-resistance heated bell furnaces used for stress relieving, sintering, nitriding, malleablising and brazing, but more particularly for bright annealing under protective atmospheres. Leaflet showing some typical recent installations.

Crucible Furnaces. MONOMETER MANUFACTURING CO. LTD., Savoy House, 115-116 Strand, London, W.C.2. Oil or gas-fired crucible furnaces of various types, including hydraulic twin-ram lip-pour tilting furnaces, central-axis tilting furnaces, and lift-out and bale-out furnaces, for melting non-ferrous metals. Illustrated leaflet.

Refractory Shapes. REFRACTORY MOULDINGS & CASTINGS LTD., 10 Market Place, Kegworth, near Derby. Tubes, muffles, electric-furnace element supports, trays, tiles, nozzles and other shapes in molochite, alumina, silicon carbide, sillimanite and zircon-zirconia refractories. Brochure No. 358.

Welding Cables. MERSEY CABLE WORKS LTD., Linacre Lane, Bootle, Liverpool, 20. Normal and heavy-type copper and aluminium electrode-holder flexible cables and copper distributor cables. Tables of weight, number and sizes of wires, overall diameter and other data. Leaflet.

Heat and Abrasion Resisting Castings. BLAW-KNOX CO., National Alloy Division, Pittsburgh 38, Pennsylvania, U.S.A. High-temperature corrosion-resisting and abrasion-resisting castings, mostly of the high-nickel and chromium type; their properties and uses. Bulletin No. 2537.

Dielectric Fluids. MONSANTO CHEMICALS LIMITED, Monsanto House, 10-18 Victoria Street, London, S.W.1. Properties and applications of the dielectric fluids, Aroclors and Pyroclor in capacitors, transformers and other electrical equipment. Brochure.

Electrical Equipment. ATELIERS DE CONSTRUCTIONS ELECTRIQUES DE CHARLEROI, Charleroi, Belgium. The firm's activities in the manufacture of electrical, electronic and nuclear equipment set out in a 96-page brochure containing some hundreds of reproductions of photographs.

Transfer Ladle. MONOMETER MANUFACTURING CO. LTD., Savoy House, 115-116 Strand, London, W.C.2. Hydraulic tilting-truck transfer ladle for conveying molten metal from a furnace to a casting-pouring station or for feeding holding furnaces for die-casting. Illustrated leaflet.

NEW

Sound Pulses. By F. G. FRIEDLANDER. *Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1.* (40*s.*)

The monograph attempts to fill a gap in the literature of the theory of sound by providing a description of the theory of sound pulses and its recent developments. It does not claim to be a complete survey of the field. It is based throughout on the scalar wave equation of acoustics (a linear approximation that can only be applied to small disturbances) and is essentially an essay on the pulse solutions of the wave equation. The mathematical problems are in many respects similar to those encountered in optics and the theory of electro magnetic waves.

Pumps, Fans and Compressors. By A. de KOVATS and G. DESMUR. *Blackie and Son Limited, 17 Stanhope Street, Glasgow, C.4.* (45*s.*)

"Pompes, Ventilateurs, Compresseurs" was published in French in 1953, by Dunod, Paris. The present translation is by Mr. R. S. Eaton, Manchester College of Science and Technology. The book, intended mainly for practising engineers with a background of the fundamentals of hydraulics, aerodynamics and thermodynamics, deals with the design, construction and operation of centrifugal and axial-flow pumps, fans and compressors. It is based very largely on experimental results that have been proved in actual practice. The ground covered includes the fundamentals of turbo-machinery, flow

Book Reviews

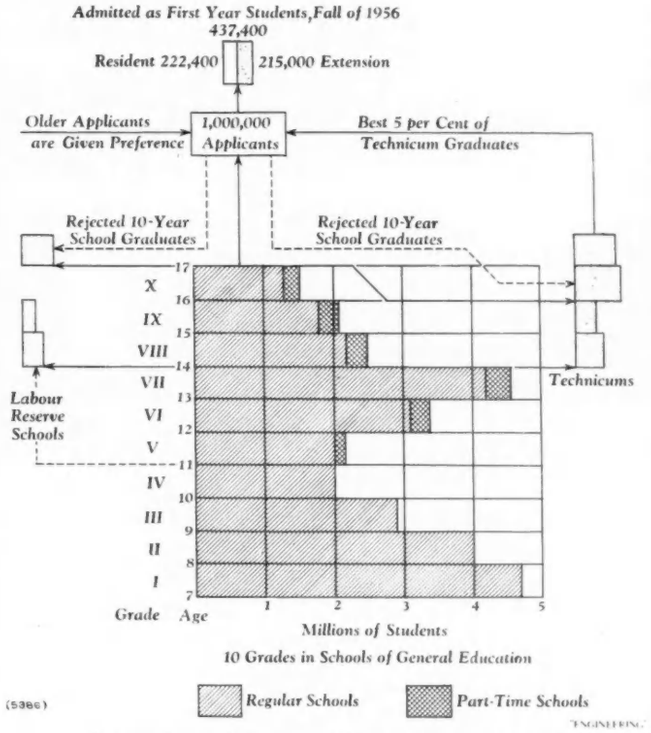
SOVIET ENGINEERING EDUCATION IN DETAIL

Soviet Education for Science and Technology. By ALEXANDER G. KOROL. *Chapman and Hall, Limited, 37 Essex Street, Strand, London, W.C.2.* (68*s*.)

Although visits by experts have played an increasingly important part in recent years in providing information on the means by which the Soviet Union is increasing its supply of scientists and engineers, it is the Russian research centres at American universities which have provided the detailed facts. The vast resources available in the United States for this type of inquiry are well illustrated by this valuable study, undertaken between 1953 and 1957 by the Center for International Studies of the Massachusetts Institute of Technology.

The general outline of Soviet education is now fairly well known: the aim of a universal ten-year school system, the Secondary Technical Schools (*Technicums*) for the training of technicians, and the universities and professional institutes for higher education. The progression from school to higher education is well illustrated by the chart here reproduced. A number of new features are brought out by this study. A large part of the expansion in higher education is taking place by means of extension (evening or correspondence) courses. Even when the numbers of evening students are added to those of resident students, they only amount to 7 per 1,000 of the population compared with 17 in the U.S.

But in Russia the proportion of engineering students is more than twice that in the U.S.



Progression to higher education in the Soviet Union.

In addition, the number of technicians being produced is very much higher than in either the United States or this country and a new 2½ year technical course has been introduced for graduates from the ten-year schools. In 1956 there were 1·3 million competing for 220,000 places in universities and other institutes of higher education, while 200,000 had to be content with correspondence courses; the problem of their employment may be causing second thoughts in the plan to make ten-year education universal by 1960. It is probable that after seven years' schooling, any sort of vocational training (for example in a labour reserve school) will count.

There is no difficulty in the Soviet Union in getting enough students for science or engineering. Both propaganda and prestige are employed to encourage recruitment and, in a society where the political pressure is unrelenting, there are attractions in jobs which are strictly professional and politically neutral.

The question of the quality of Russian education is obviously more difficult to answer than that of its system and organisation. An attempt is made here to deal with this by detailed descriptions of curricula and examination papers and these will be of value to those interested in comparative education. According to the author, the centralised system of Soviet education has the advantage that it enables both its quantitative development and its standards to be controlled. Its disadvantages are bureaucracy and the paralysis of individual academic initiative. A much more penetrating study of individual institutions on the spot would be required finally to confirm these findings; but certainly since Stalin's death there has been a growing pressure in this sphere, as elsewhere, for decentralisation. Great efforts are also being made, as in other industrial countries, to improve the level of engineering education, particularly by broadening its scientific base.

BOOKS

through ducts, flow round aerofoils and cascades, and hydraulic power lines; the design and construction of impellers and diffusers; the construction and operation of pumps and fans; special duty pumps, and turbo-compressors.

Causes and Prevention of Corrosion in Aircraft. By T. C. E. TRINGHAM. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, W.C.2.* (25*s*.)

The author's aim is to present a practical guide to the causes of corrosion, and the measures that should be taken to prevent its incidence, from the viewpoint of aircraft inspection and maintenance engineers. After an introduction to the various forms of corrosion and their causes—with particular emphasis on the corrosion-fatigue and stress-corrosion troubles to which the post-war high-strength wrought-aluminium alloys have proved to be prone—the sources of corrosion in manufacturing processes are discussed, followed by suitable storage procedures and the consideration of corrosion causes and protection of aircraft in service. Subsequently the author deals with corrosion in engines and their associated components; electrical equipment; the electroplating process and the necessary precleaning; anodic oxidation and chromating; metallising; paints and other protective coatings; methods of non destructive examination; and the salvage of aircraft parts that have been corroded.

On the Shelf

By Frank H. Smith

At 7·50 dols per annum, Interscience Publishers (250 Fifth Avenue, New York, and 88 Chancery Lane, London, W.C.2) are producing (four times a year) *Research Management*, whose " broad objectives include the encouragement of improved industrial research management, the development of an understanding of research as a force in the life of the nation and the promotion of high standards in the field of industrial research." The journal is sub-titled " A publication of the Industrial Research Institute." The first number has articles on " Creativity Techniques in Action," " The X-ray Image Amplifier," " Experimental Design: A technique for getting Most Information at Least Cost," and " Information Research." If this has whetted any appetites—I'm glad. The penultimate title has nothing to do with underpaid librarians.

There is more news of this grant-in-aid business by the National Science Foundation for translations from the Russian. It is all rather complicated but, as far as I can make out, *Avtomatike I Telemekhanika* has been translated by Consultants Bureau Inc. since 1956 at 185 dol a year. This is steep, even by American standards. The same firm will continue to do the donkey-work but, in future, distribution will be through the Instrument Society of America at lower rates, thanks to the grant to Massachusetts Institute of Technology by the National Science Foundation. (If only my public realised the way I simplify their reading matter.) The grant brings the subscription down from the figure I gave to 30 dol in the United States and Canada, 33 dol elsewhere, and, to libraries of academic and non-profit making concerns, 15 and 18 dol. Which just goes to show what a little grant, aiding can do. Interested? Write to Instrument Society of America, 313 Sixth Avenue-Pittsburgh, 22, U.S.A. Oh, by the way, the journal is about automatic control. It's just as well to know.

If you apply to the Technical Librarian, Central Library, St. Peter's Square, Manchester 2, you can have, gratis, a copy of " What's Available in the Technical Library," which is a " survey of some of the resources in addition to books," by F. R. Taylor, technical librarian. It is a 12-page pamphlet packed with information.

To the average person SINTO sounds like something from the Far East, but to commercial interests in the cutlery district it means Sheffield Interchange Organisation, a body formed for the dissemination of information centred on the Central Library at Sheffield. John Bebbington, the City Librarian and Information Officer, has just sent me the 1957-8 Review of Progress and tells me that SINTO has been going for 25 years. Membership is open, without charge, to firms or institutions in the Sheffield area which possess a research library or a collection of not less than 50 technical books and 10 current periodicals. At present there are 46 members, which, between them, must provide a very comprehensive technical information machine, and I certainly and earnestly suggest that any non-member in the district who qualifies should get in touch with the Librarian, Science and Commerce Library, Central Library, Sheffield 1 (24031 Exts. 3 and 19). If anybody interested has not the required minima quoted he (or she) can try under a scheme which caters for special exceptions.

The editor of *Film User*, 319 High Holborn, W.C.1. CHA 5238, makes a good point in a letter when he points out that there are lashings of films available for free showing if only one knows where to apply—and one usually does not. Anyway, *Film User* proposes to fill this long-felt want and will provide a directory in its August issue, BUT it wants anybody who has films and who has not already filled in that journal's questionnaire to get in touch.

Design

HIGH-SPEED PASSENGER LAUNCH

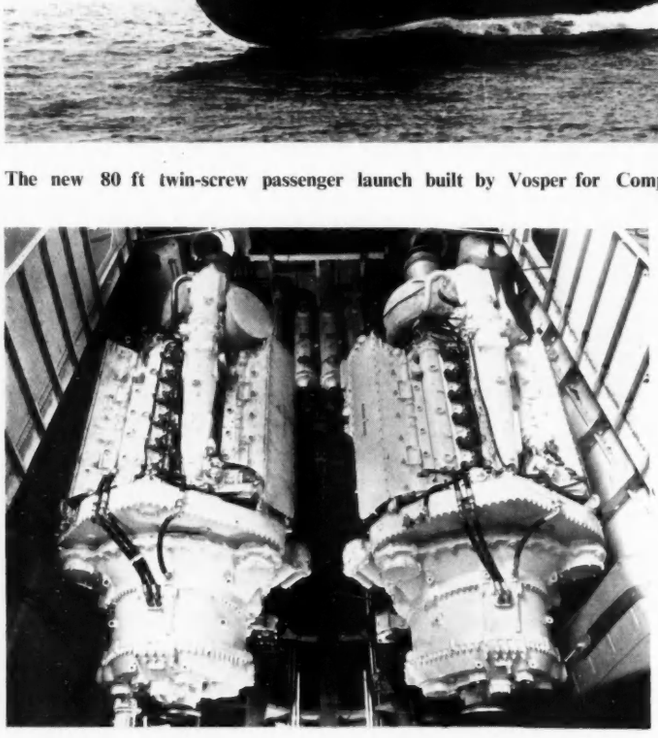
Manoeuvrability for Venezuelan Lake Service

The new 80 ft twin-screw passenger launch built by Vosper for Compania Shell de Venezuela cruises at 35 knots.

Towards the end of this month, Compania Shell de Venezuela will take delivery of a new 80 ft express passenger launch, "PL4 Maracaibo," for use on Lake Maracaibo, Venezuela. The design and construction of PL4 was carried out by Vosper Limited, Portsmouth. The launch is to serve new oil concessions farther out in the lake, involving distances up to 75 miles. To keep down travelling time, therefore, a cruising speed of 35 knots was stipulated for the craft, and provision for carrying up to 60 passengers was specified.

Other design features to cater for the operating conditions on Lake Maracaibo—where floating logs and debris are one of the navigational hazards—are a high steering position well forward to give coxswains the best possible vision, a ready response to the steering control, and rapid "stop-ability." In meeting these requirements, Vosper have worked in close collaboration with Compania Shell de Venezuela and Shell Tankers Limited (the latter company actually ordered the craft for their Venezuelan associate).

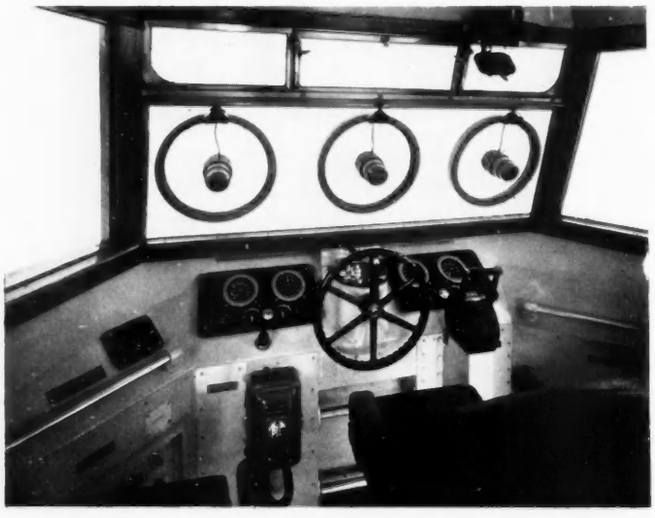
The leading particulars of PL4 are given below. Her main propulsion units are two Napier Deltic two-stroke diesel engines, type 18-25K, each giving 1,620 b.h.p. at 1,500 r.p.m. They are a development of the Deltic motor-torpedo-boat engine as used by many navies throughout the world, but de-rated for commercial use to increase the overhaul life. Accommodation is provided for a crew of three and four passengers in the wheelhouse, and 56 passengers in a passenger saloon at the forward end. The engines are below and aft of the saloon.



The engine room, looking aft between the two 1,620 b.h.p. Deltic engines.

Leading particulars of PL4

Keel laid	2 August, 1957
Launched	22 January, 1958
Trials commenced	5 June, 1958
Length, overall	80 ft
Beam, moulded	19 ft 9 in
Depth, moulded	9 ft 2 in
Duration and speed	8 hours at 35 knots
Fuel capacity	Two main tanks 540 gal each Reserve tank 140 gal



Engine starting and running is controlled entirely from the wheelhouse, which is located high and well forward for good visibility.

FULLY CAVITATING PROPELLERS

The most interesting feature of PL4 is the use of high-speed propellers, developed in Vosper's cavitation tunnel. The drive from the engine passes into an integral reversing gearbox and thence to a Napier V drive. As there is no reduction gear, the final propeller speed is equal to that of the crankshaft.

The philosophy behind the small high-speed propeller is briefly as follows. Although, theoretically, optimum propulsive efficiency is obtained by using a large diameter propeller turning slowly, in high-speed craft such propellers have disadvantages. Installed under a planing bottom, a large diameter screw involves setting the shaft at an appreciable angle to the general flow direction. In consequence there is a marked cyclic variation in the effective blade incidence, which can result in alternate face and back cavitation occurring during each revolution, often producing serious erosion, usually on the back surface of the blade. In some instances a propeller blade has been "eaten" right through after a few hours running. Also, the angularity of the shaft and the necessity for cumbersome support brackets give rise to a considerable appendage drag.

If a smaller diameter propeller is used, rotating at high speed, although its theoretical efficiency will be lower, so also will be its appendage drag and the balance may be in favour of the smaller high-speed screw. Moreover, in contrast to the large wide blade of the slow-speed propeller, the relatively small high-speed blade can be designed so that, throughout a wide range of speed, the blade back is fully cavitating—that is, from the leading edge to well aft of the trailing edge there is a cavity on the blade surface filled only with water vapour. Under such circumstances, the collapse of the nuclei takes place well downstream and not on the blade itself. In the case of PL4's high-speed propellers, underwater inspection after 34 hours of high-speed running has revealed no sign of erosion either on propellers or on the rudders. An overall propulsive efficiency of 57 per cent has been achieved—a good figure in this class of work.

ASTERN FROM FULL SPEED AHEAD

The need for rapidly decelerating the launch is most effectively satisfied by the Deltic engines, which incorporate a patent Napier device whereby astern can be selected from full speed ahead, enabling the craft to come to rest in approximately two boat lengths. The combined throttle and reverse gear controls are by Teleflex. The Deltic engines also have fully

ORGANISATION OF CHEMICAL ENGINEERING PROJECTS

Co-ordinating a Complex Venture

What is a project engineer? Is he the master expert in all engineering fields? Is he the "Jack of all trades and master of none"? Or is he primarily an organiser and co-ordinator getting out the project programme and welding the whole task together? This was the main question which arose from the "Joint Symposium on the Organisation of Chemical-Engineering Projects," organised by the Institution of Chemical Engineers and the Institute of Petroleum and held in London on 24, 25 and 26 June. It was agreed that good planning was the essential feature of any chemical-engineering project and the symposium itself was a good example of this work by chemical engineers. Held at the time of the Chemical and Petroleum Engineering Exhibition at Olympia, it enabled some 625 engineers to visit London and attend both functions.

The first paper by Sir Leonard Owen and Mr. C. J. Turner, with the title of the main symposium, gave a formal account of the manner in which a chemical-engineering project was brought to fruition. It described the organisation provided for the chemical plants built at Dounreay and showed that the key to project success was the centralisation by the United Kingdom Atomic Energy Authority of the executive authority in the project engineer. The project engineer on this task was responsible for the whole project with the charge of handing over the plant to the operators at the right time and the right place. The lines of authority, within the project organisation, were clearly defined and made known specifically to all members of the staff. This made for more efficient operation of the task.

BAR-LINE PROGRAMMES

Sir Leonard admitted that the type of project engineer that such an organisation called for are men who are specialists but who are able to look over the complete schedule. They, unfortunately, are few and far between and for this reason the Industrial group of the UKAEA is training its own project engineers.

The paper gave an account of the practice followed in the co-ordination of design by means of committees composed of all interested technical and scientific personnel and of the systematic review of the progress of construction throughout all its phases. Emphasis was placed on the value of bar-line programming throughout the work and on the importance of site selection layout. The final section of the paper covered cost estimating and control.

As with other types of project, the UKAEA uses models for pre-planning. These, however, are mainly for architectural reasons owing to the public interest in such projects. The Industrial Group project engineer did not control the letting of contracts. This surprised several members of the audience during the discussions but Sir Leonard was firm that in his view the functions should be separate. The project engineer, however, did bear responsibility for deviation from the original cost. Several speakers thought this was hard on the project engineer but Sir Leonard remarked drily that it was all a matter of habit.

In the second paper, "Design Duty and Specification of Requirements, including Site Selection," by Mr. J. B. Asquith and Mr. L. S. Davis, a chemical-engineering project was considered from a project engineering contractor's point of view beginning with the first idea and following the basic steps up to a stage when it was ready for execution. The authors emphasised that the key to the satisfactory preparation of project information at this stage depended very closely on client-contractor co-operation. The information given by the client must be relevant. Very often complicated irrelevant information is given and the contractor could help by specifying exactly the simple information he requires at this stage for a first perusal. Naturally, considerably more information is required to make a final scheme after the initial investigation.

PAYING FOR DESIGN STUDIES

During the discussion the important point concerning whether contractors should carry out detailed investigation for clients at no cost was considered. The authors stated that the contractor's point of view was that he could not offer to carry out detailed project considerations if the chance of payment, through the scheme becoming a firm project, were very limited. For this reason the contractor felt that it was unfair to request many companies to submit bids on projects. If only two or three were so requested this gave the contractor a fair chance of success. Alternatively, the client should be prepared to pay for a detailed design study of his project. Some design studies have been prepared on the basis that the client payed for the study but that the money was refunded to the client by the contractor if the project went ahead. From the discussions that followed it was obvious that this was a difficult subject and one on which many views were held.

The next two papers covered "Systems of Project Organisation." The first by Mr. K. M. Curwen, given from the point of view of the client, and the second by Mr. R. E. Bywater, from the point of view of the contractor.

Mr. Curwen strongly emphasised the use of models in project organisation. He recommended that, firstly, simple models of two or three different layouts should be prepared, the most suitable should then be considered with medical, safety people, and others. This final model should be made without pipework to enable structural steel and vessels to be sent out to tender. Pipework on the models was then completed and contractors requested to quote for erection. It was known from experience that contractors could tender much more easily, and, it appeared, at a lower price after seeing the model than by basing their quotation on drawings. The model was then sent to the site to assist work there. The project mainly considered in Mr. Curwen's paper was one of approximately £150,000 totally erected price and the model cost approximately 1 per cent of this sum. In all, it was estimated that nearly four months were saved by the use of the model in the total project time. It was also estimated that better layout of the plant, due to this model, saved some 3 per cent of material cost and about £2,000 (or perhaps some 2 per cent) of the erection price. In all, about 11 per cent of the totally erected price was saved, i.e., some £16,000, and this was considered mainly due to the use of the model. Finally, the model was a good record of the plant after the project had been completed and was kept for that purpose.

Mr. Bywater emphasised his agreement that the planning of a project was essential but that before doing this one must plan one's own planning offices. His paper described how the contractor organised his staff to deal with all aspects of the project planning, design detail, purchasing, progressing, erection and testing, commissioning and final construction. In both papers the importance of the project engineer was again emphasised.

The two papers which followed covered the "Function of the Contractor" and were presented by Mr. L. B. Baker and Mr. W. H. A. Webb, respectively.

Mr. Baker made a very strong case for the use of contractors in project engineering construction. There were many reasons for this being an advantage. For instance, small and medium-size companies did not usually have staff available for process development. In addition, all the general experience gained by the contractor on many types of plant is embodied in his approach to a client's requirements. In Mr. Baker's opinion the final result was usually a more efficiently run project.

COST-PLUS CONTRACTS

The question of the type of contract that the contractor could offer depended very much on the type of information given by the client in the first stages. If the design were not settled then naturally some form of cost-plus contract would be essential. If it were reasonably settled, but agreed that the detailed designs might bring forth changes, then the most suitable scheme was to have the contractor's service charges (design, engineering, procurement, site supervision, etc.) fixed for a specified project with the materials, equipment, etc., paid for at net market price by the client. Finally, if the design were firmly fixed, for instance if it were a repeat of a previous installation or if the client had had prepared (or wished prepared) a detailed estimate of every item of the project, then a firm totally erected price could be given. This latter scheme, however, was not usually possible and the fixed services type of contract was considered the best and most usual.

During the discussion on this paper the point was made that it was essential for the client to bring the contractors into discussions at an early point on a project so that all their experience could be placed at his disposal in planning, site selection phases, and so on. It was agreed that the major contribution a contractor could make to a project was to provide the extra

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Continuing **High-Speed Passenger Launch**

automatic starting and protection equipment, giving complete control from the wheelhouse (starting is by compressed air).

Exceptionally good steering control is provided by Mathway electro-hydraulic power-assisted steering gear—in recent demonstration runs on the Solent, the coxswain showed his confidence in the gear by repeatedly aiming the PL4 at full speed to within inches of the stern of another vessel. Alternative manual control of the steering gear is possible in the event of power failure.

The PL4 has an all-welded steel hull and a welded aluminium-alloy superstructure. The hull is of the hard chine form, and has been the subject of much detailed thought by Vosper, in order to avoid the characteristic slamming in a seaway often associated with this type of craft. Subsequent trials have confirmed that comfortable riding conditions have been successfully achieved. Ventilation trunking with directional punkah louvres is fitted throughout the superstructure space, with two centrifugal fans supplying the passenger saloon and an axial extractor fan for the toilet.

Electrical power (24V) is provided by a 1½ kW Lister direct-current diesel-generator set, and a 3¼ kW generator driven from the front-end power take-off of the starboard main engine. The 24 V battery has a capacity of 130 Ah. Radio and navigational equipment includes a Pye Ranger frequency-modulated V.H.F. transmitter-receiver, a Linwood's PL12 aircraft-type compass, and three searchlights.

The official trials of PL4 have been completed very satisfactorily; over the Stokes Bay measured mile, an average speed of 37·35 knots was recorded.

Continuing Design

effort and new ideas beyond what the client already could achieve.

Mr. Webb, in his contribution, also argued that it was logical for a client to choose a single contractor at the outset and obtain his co-operation. Such a choice was influenced mainly by the experience possessed by the contractor in dealing with projects of the size envisaged. Thus the contractor would be able to take the initiative in many phases of the client-contractor collaboration. Naturally the contractor must continually report on his progress to the client and this should be specifically stated in the contract.

During the discussion a call was made for standard conditions of contract to be prepared for application to chemical-plant contracts, but it was agreed that with the many types of project which are being handled and the varying degrees of work which the contractor offers, such a standard set of conditions would be difficult to prepare. It was agreed, however, that further thought could be given to this important problem.

PROGRAMMING AND ESTIMATING

The next two papers, both entitled "Programming and Progressing Systems and Meeting Completion Dates," were given by Mr. J. O. Dugdale-Bradley and Mr. W. V. M. Kelly.

Both papers gave in considerable detail the method of organising and controlling by charts, etc., a chemical-plant construction project. Several types of chart control were shown and the merits of each described and the desirability of phasing the various sections of the work was emphasised in order that they might all mature together. A close follow-up, using all the assembled data, was shown to be essential for ensuring that the task was adequately co-ordinated and kept on schedule. The various responsibilities of the project and contract engineer were given with their corresponding spheres of interest.

It was also pointed out that all personnel engaged on a project must have clear terms of reference. Early freezing of design, prompt ordering of materials and equipment, adequate supervision, and liberal use of erection equipment were important for a project's success. Close client-contractor relationship was essential and good relations between their staff would enhance the appreciation of the many problems facing them and emphasised the need for the prompt co-ordination of decisions.

Mr. P. Brett presented a paper on "Cost Estimating and Control." He classified three types of capital estimate which could be prepared according to the time available. Type A was that prepared in a few minutes, type B was prepared in a few hours, and type C was prepared in days or weeks. Before commencing any estimate it was essential for the estimator to be completely clear concerning the extent of the ground which he was to cover. It was useful to draw an imaginary line around the plant excluding the services such as steam, cooling water, etc., and also the buildings which housed offices and changing rooms. Mr. Brett's paper was concerned with the plant within this line.

To avoid delaying the proposal it was important not to waste time estimating to a higher accuracy than was warranted by the particular stage reached. Less accurate estimates could be done in minutes either by analogy with existing plants or by multiplying purchase cost of the plant equipment by a factor. By spending a few hours on the estimate of equipment its accuracy could be improved and a more considered factor chosen. Alternatively the total could be obtained by adding to the equipment cost the other costs, such as buildings and instruments, each obtained by multiplying the equipment cost by a factor. When an accurate estimate was required, with more time available, it was still often necessary to estimate the cost of erection and pipework in this way.

The final section of Mr. Brett's paper covered cost control, the checking against the estimate as each order is placed by the engineer ordering equipment and the preparation every so often of "expenditure and commitments" figures to date. The staff concerned with the preparation of "E & C" control estimates often included some of those who were actively working to finish the project by the deadline date. It was therefore, important that the management ensured that control estimates were not demanded except where they had a really important purpose to serve.

The first two papers on Thursday, 26 June, covered "Plant Commissioning," and were presented by Mr. D. W. K. Barker and Mr. A. F. Cottrell, respectively.

The first paper described broadly a firm's experience in commissioning a large new "grass-roots" oil refinery in Australia. The particular emphasis was given to the important factors on which prompt and trouble-free commissioning was considered to depend, namely, the close co-ordination of construction and commissioning programme; the elimination, by exhaustive trials, of the risk of mechanical failure; the selection, training and conditioning of staff and labour; and the strict adherence to detailed procedures.

Mr. Cottrell's paper covered the commissioning of a coke-oven plant. In addition to describing the technical control through initial testing, heating up and construction, a section was devoted to the training and grading of personnel. Emphasis was laid on the early preparation and strict adherence to a time-table.

The last two papers of the symposium covered "The Analysis and Future Use of Project Records," by Mr. S. T. Card and Mr. R. Adams.

Mr. Card again raised the question of the position of the project engineer which had been continually present during the symposium. Mr. Card described his belief that the project engineer is the key man in a project directly responsible for getting the project done. He was primarily an organiser and co-ordinator getting out the programme, issuing the various specifications to the specialist sections and welding the whole together. The project engineer was also in charge of site construction.

Mr. Card's paper examined the project records maintained by an engineering division which had its own design staff and specialised technical section. It also carried out the procurement, inspection and progressing of plant and equipment and the supervision of construction work for which outside contractors were normally employed. The records kept for such a project were classified as follows: engineering and design; procurement, inspection and expediting; financial and estimating; administration; and operation. The records were discussed from the point of view of the application of lessons to be learned from them in future projects, bearing in mind the three main criteria of success in project work, namely, completion to technical specification, completion within the time programme, completion within the financial authorisation.

PLEA FOR SCHEDULES

Mr. Adams's paper pointed out that the task of analysing project records was (*a*) to check the data on which the projects were based to find an explanation of any discrepancies, to locate means of improving efficiency, and (*b*) to amend and extend the data as a result of further experience. Such analyses, which must be carried out by competent and experienced personnel, cannot be more accurate than the data upon which they are based, and task records must be as factual as is reasonable and should be accompanied by notes of any influencing circumstances. The criteria for records depended on whether they were any use and whether they were going to be used. During the discussion, a strong plea was made for more estimating information to be published. A certain amount was being released in America but more was required, particularly from Britain.

Also during this discussion a plea was made for the possible inauguration of a Federation of Chemical and Petroleum Plant Contractors. A corresponding Federation in Civil Engineering had schedules of rates for various projects, trades, etc., and if such could be applied to chemical and petroleum projects it was felt that they would run much more smoothly.

SPEEDING UP A NORTH-SEA PASSAGE

The "Bolton Abbey," the first of two passenger-cargo motorships constructed by Brooke Marine Limited, Lowestoft, for the British Transport Commission's Hull-Rotterdam service, is the largest ship so far built by Brooke Marine, and the largest ever launched from a Lowestoft yard. The ship will cut the passage time between Hull and Rotterdam by about four hours, and with her sister ship, the "Melrose Abbey," now being built, will enable more frequent services to be operated between the two ports.

Built to the design of Burnett, Corless and Partners, consultants to the British Transport Commission, the Bolton Abbey has an overall length of 302 ft 4 in, a moulded breath of 45 ft, a summer draught of 14 ft, and a deadweight capacity of 1,080 tons. The twin screws are driven by two Ruston and Hornsby 8VOXM oil engines through reverse reduction gearboxes. With a continuous rated output of 1,806 b.h.p. at 190 r.p.m. at the tail shaft the engines give the ship a loaded speed of 15½ knots.

The first of two sister ships, the M.S. "Bolton Abbey," is designed to carry passengers and cargo on the British Transport Commission's Hull-Rotterdam service.

A break with tradition is made in the design of the ship, which has the machinery, bridge and all accommodation for passengers and crew aft, to leave a clear space forward for loading, stowage and discharging. Particular attention has been given to the possible development of traffic in goods loaded in pallets or containers, and the 'tween decks are specially adapted for this purpose. McGregor sliding steel hatch covers are fitted throughout, and No. 2 hatch is 60 ft by 25 ft, making it possible to handle large containers and long consignments. All the cargo spaces are mechanically ventilated on the Thermotank principle for the carriage of perishable goods.

Accommodation is provided for 80 passengers, in single and two-berth cabins, and there is a large lounge and bar and a restaurant; all this accommodation is on the same deck. Fire-proofing has been given special attention, the ship being fitted with a comprehensive sprinkler system, as well as smoke-detection and CO_2 equipment. Thermotank heating and ventilating is provided in the passenger and crew accommodation.

The Ministry of Transport safety requirements are met in full by the provision of two Viking Fibreglass lifeboats on Schat davits, together with six Beaufort 20-person inflatable life-rafts. Navigational aids include a Decca Navigator and Mk. 5 radar, Marconi wireless-telegraphy and direction-finding equipment, Kelvin Hughes echo sounder, and Chadburn electric telegraphs.

DIESEL-HYDRAULIC LOCOMOTIVE OF 2,200 H.P.

The first main-line 2,200 h.p. diesel-hydraulic locomotive of British Railways' own construction, No. D800, which has recently completed trials, has been named "Sir Brian Robertson." It is the first of 33 of its type being built at the Swindon works of the Western Region for use on the West of England routes, and is shown below leaving Paddington on a trial run to Reading.

The first main-line diesel-hydraulic locomotive introduced by the Western Region in February this year was the D600. It was built by the North British Locomotive Company (ENGRG., 7 March '58, p. 316). D800 and her 32 sisters are based on the same principles of power and transmission and, collectively, they will be known as the Warship Class. The design is, in fact, based upon that of the V200 locomotives of the German Federal Railways, which have proved very successful in service. Many features are comparatively new to railway practice in the United Kingdom.

"Sir Brian Robertson," the first diesel-hydraulic locomotive built in British Railways' workshops.

Although based on the V200 design, the restrictions of the British Railways loading gauge necessitated a height reduction of approximately 10 in and a width reduction of 16 in, which caused many problems from the point of view of space and accessibility. A high power-to-weight ratio has been achieved by the use of stressed skin construction, the superstructure carrying a considerable portion of the weight of the locomotive. The weight thus saved is between 30 and 40 tons, equivalent to the weight of one coach. One advantage of the low weight is that the locomotive, although having a nominal horsepower of 2,200, can be carried on two four-wheeled bogies without the axle load exceeding 20 tons. The bogie design is one of the features of unusual interest. Welded construction is used practically throughout the locomotive.

The locomotives, which are included in the British Railways classification as Type 4, are designed for operation in multiple with each other. The principal particulars are given below:

Length over buffers	60 ft
Weight in working order	78 tons
Fuel capacity	800 gallons
Water capacity	1,000 gallons
Maximum service speed	90 m.p.h.
Maximum tractive effort at 30 per cent adhesion	52,400 lb
Driving wheel diameter	3 ft 3½ in
Bogie wheelbase	10 ft 6 in

The centre of the bogie, which is built up of welded mild-steel plate (centre illustration), is a hollow rectangle into which projects a part of the underframe and the lower part of the transmission containing the output shaft and flanges. The traction and braking forces are transmitted between bogie and underframe by curved manganese-steel rubbing plates. Transverse forces are transmitted by a linkage system connecting bogie to underframe, which allows the former to turn relative to the latter about a geometrical centre.

The body weight is transmitted to each bogie through brackets pin-jointed to the buckles of two large laminated springs. From these springs the weight is transferred through coil springs to the bogie frame, and thence by laminated springs to the top of the roller bearing casings and finally to the axle. Each bearing is contained in a casing forming an arm connected to the bogie frame by large pins with flexible rubber bearings.

Two Maybach 12-cylinder V-type MD 650 "tunnel" engines are pressure-charged by single-stage exhaust-gas turbo-chargers of Maybach make. The crankshaft, with the main roller bearings, is introduced into the one-piece crankcase from the front end of the engine; hence the designation "tunnel" engine. The engine speed control is electrical and six speed notches are provided, the actual speeds being readily adjustable if required.

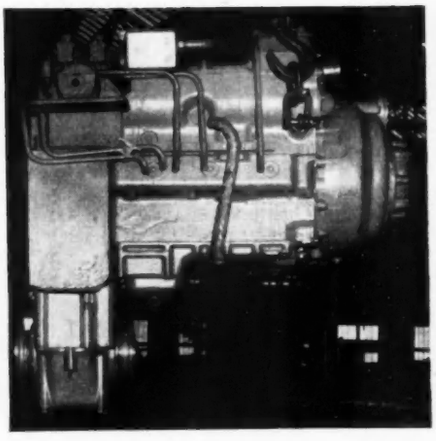
Two Maybach Mekydro type K 104 hydraulic transmissions are fitted, one being illustrated. Each is connected through a cardan shaft to its appropriate diesel engine. The cardan shaft is similar to that used on the V 200 locomotives. The K 104 transmission has four speeds and consists essentially of a single torque converter permanently filled with oil, together with mechanical change gears in permanent mesh. The actual gear changing is accomplished by means of overrunning dog clutches. The necessary torque relief while changing gear is obtained by withdrawing the turbine blades of the converter in an axial direction. This is done automatically by hydraulic pressure. The control mechanism for gear changing is oil-pressure operated, and initiates the change fully automatically in relation to the locomotive and engine speeds. The reverse gears are contained within the transmission casing, the direction of change being controlled by electro-hydraulic means. If the reversing handle in the cab is operated while moving, no forward/reverse gear change is made until the locomotive comes to rest. The drive from each hydraulic transmission to the axle-mounted Maybach gearboxes is through two cardan shafts each having two universal joints. These cardan shafts are also similar to those used on the V 200 locomotives.

Welding the mild-steel plate bogie frame.

A dynostarter is provided for each engine. When acting as a generator, the dynostarter supplies current for engine speed control, the various auxiliaries and charging the battery. When acting as starter, the starting current is drawn from a 56-cell lead acid battery.

The radiator, cooling fan and motor, header tank and associated pipes are supplied by Serck Radiators Limited as a complete unit for each engine. The fan drive, cooling-water temperature control and shutter-actuating device are of particular interest, being the first of their type on a main-line locomotive in this country. The fan is driven by a hydraulic motor using oil at a pressure of 1,500 lb per sq. in. The pressure is supplied by a hydraulic pump which is an exact replica of the motor and is driven directly from the free end of the diesel engine through two Layrub flexible couplings. The pressure of oil to the motor, and hence the speed of the fan, is controlled by a thermostatic valve in the cooling water system. This valve also controls hydraulically-actuated shutters on the outside of the radiator units, regulating the flow of air through the units. The normal cooling-water temperature is approximately 170° F. The cooling-water circuit includes the engine, lubricating oil and piston-cooling-oil heat exchangers, also the transmission torque converter and torque-converter oil heat exchanger. Means for heating the cooling water is provided, and to reduce cylinder wear the engines cannot normally be started until the water temperature has reached 130° F.

A Laycock-Knorr vacuum-controlled straight air-brake system is fitted, in which the driver's vacuum brake valve applies the train brake and makes a proportional application of the locomotive air brake. By means of the driver's air-brake valve the locomotive brake only can be applied. A "passenger/goods" cock is provided in each cab, by means of which, when placed in the "goods" position, the normal proportional brake application is slowed down. A deadman's system of brake application is also included. The application is in two stages, between which a delay occurs, allowing "bunching" of the train before the brake is fully applied. The engines are automatically reduced to idling.



The Maybach Mekydro transmission consists essentially of a torque converter with mechanical change gears in permanent mesh.

The Western Region system of automatic train control is fitted, in which the emergency automatic brake valve functions in parallel with any partial brake application which is not initiated by the driver. It responds also to the opening of a passenger communication valve.

The D800 series of locomotives are designed and constructed under the overall direction of Mr. R. C. Bond, chief mechanical engineer, British Railways Central Staff. The details of design and construction are the responsibility of Mr. R. A. Smeddle, chief mechanical and electrical engineer, Western Region.

Continuing **Design**

DIRECT DETECTION OF PRESSURE RATIO CHANGES

Fast-Response Sensor Gives Error-Proportional Signals

A mechanism for directly sensing the ratio between two fluid pressures or pressure differentials is now being made in the United Kingdom by H. M. Hobson Limited, Wolverhampton, under licence from the Solar Aircraft Company, San Diego, California. The Microjet, as it is known, was developed in the first place for the control of turbojet afterburning systems, and up to the present it has been used mainly for this and other gas-turbine applications, such as indicating the position of oblique and normal shocks in supersonic air intakes, and measuring the operating conditions in compressors and motors. For such purposes an extremely high response rate is essential, and in this characteristic the Microjet is far superior to other methods of determining pressure and flow ratios. Moreover, it produces an output proportional to the error in pressure ratio, and is independent of the absolute value of the pressures used. It is believed that the Microjet should have many applications in the processing industries, as, for example, when it is required to maintain a constant flow ratio in the mixing of liquids at varying flow rates. One such application that the Microjet has been used for in America is the dosing of city water supply with fluoride.

The Microjet shown in Fig. 1 is a compact and comparatively simple unit. In its simplest form for measuring the ratio between two gas pressures, the instrument consists of a cast metal case containing a flexible diaphragm and attached taper needle. Referring to Fig. 2, the larger of two pressures P_1 is fed through a fixed orifice (which may be fitted with a trimmer needle if required), to a compartment on the needle side of the diaphragm, and is vented to atmosphere through a second orifice controlled by the taper needle. The reduced pressure between these two orifices is a reference pressure KP_1 and is a predetermined fraction of the original pressure. The value of K depends on the position of the needle in the vent orifice. The reference pressure is equated through the diaphragm to a second pressure P_2, which means that, when the taper needle is in its datum position, the pressure P_2 is a predetermined fraction of P_1 and any deviation from this desired ratio causes the outlet needle to move an amount proportional to the error. For certain applications the taper of the needle is reversed, so that the device acts as a switch which operates between two predetermined pressure ratios. When used with liquids, or with toxic gases, some elaboration is required, since it would not normally be possible to discharge directly into ambient air.

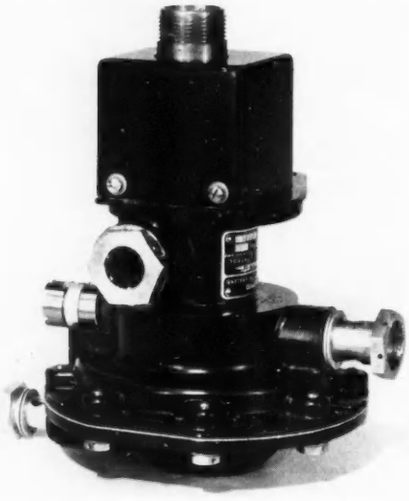


Fig. 1 The Microjet pressure-ratio detector.

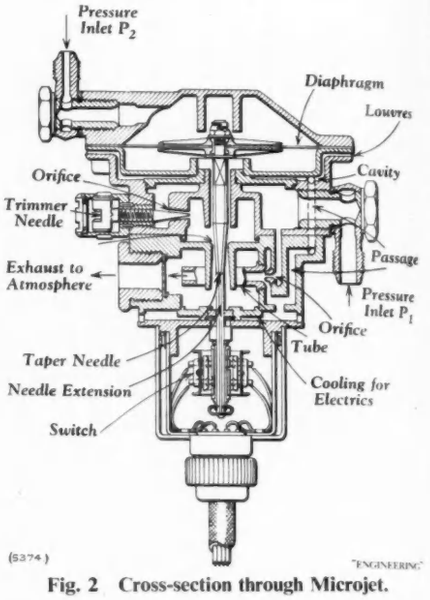


Fig. 2 Cross-section through Microjet.

In order to maintain accuracy, it is necessary to reduce forces on the needle to a minimum, and it is therefore usual to combine the Microjet with some form of powered assister, which may be pneumatic, hydraulic or electrical. If greater degrees of power amplification are required, the main servo valve may itself be power assisted, in which case the Microjet only operates a small pilot servo valve. This system is equally applicable to pneumatic or hydraulic actuation.

The set-up illustrated in Fig. 2 is in fact that appropriate for controlling a single two-position exhaust nozzle on an afterburning turbojet. The pressure P_1 is the compressor discharge pressure, and P_2 is the turbine discharge pressure. When the pilot switches on the afterburner fuel supply, the immediate change in turbine discharge pressure alters the pressure ratio, which is sensed by the diaphragm. The resulting movement of the taper needle actuates a switch controlling an electro-hydraulic servomechanism which opens the jet nozzle. A more sophisticated form of afterburner control on a supersonic aircraft embodies a second Microjet unit which alters the divergence of the nozzle in response to the Mach number change.

FASTER FASTENING

A new fastener, widely used in many industries in the United States, is now being produced in the United Kingdom by Aviation Developments Limited, Kingsbourne House, 229-231 High Holborn, London, W.C.1. Known as the Avdel Lockbolt, it replaces conventional fasteners such as nuts and bolts or solid rivets used in the fabrication of metal structures, with much faster fitting speeds.

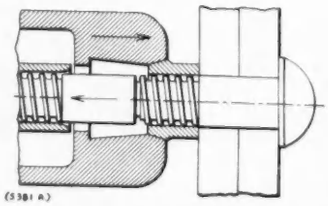
The Lockbolt assembly consists of a headed bolt, the shank of which has a series of annular locking, breakneck and pull-grooves, and a locking collar. Lockbolts are set automatically by using a portable high-speed pneumatically operated pull-gun.

In operation, the Lockbolt is inserted into a prepared hole and the locking collar placed over the protruding bolt tail. The pull-gun is then applied, the jaws in its nose automatically gripping the pull-grooves on the bolt tail. The gun trigger is then actuated and an axial pull is exerted on the bolt. The reaction to this pull is taken against the locking collar by the swaging anvil of the pull-gun so that the work is clenched tightly together.

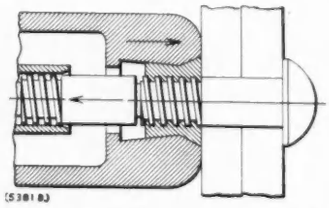
As the pull on the bolt continues, the anvil of the gun is drawn over the collar, swaging and locking it into the lock-grooves of the Lockbolt to form a rigid permanent lock. The pull continues to break off the bolt tail at the break-neck groove so that the Lockbolt is positively set at a predetermined tension. The gun then automatically disengages itself from the swaged collar.

The placing sequence of the Lockbolts is continuous, automatic and rapid so that an unskilled operator can place up to 30 bolts per minute, set at a uniform tension and finish.

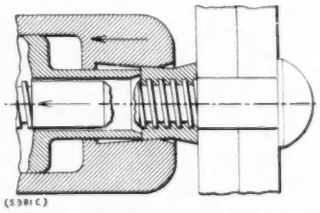
The placed Lockbolts have a high resistance to fatigue and vibration in addition to high shear and tension strengths. Initially the manufacturer is producing commercial type Lockbolts of $\frac{3}{16}$ in and $\frac{1}{4}$ in diameter in steel and high-strength aluminium alloy. Larger sizes will be produced later.



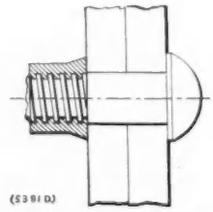
The tool grips the bolt and the sheets are clenched tightly together as the bolt is pulled into the tool.



The pull continues, swaging and locking the collar into the annular lock-grooves on the bolt.



The bolt breaks at the break-neck groove and at a predetermined tension.



The placed lockbolt, with the collar swaged into the lock-grooves to form a strong permanent fastening.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, *30 May, page 692, and 27 June, page 831. Organisers are invited to send particulars of coming events to the Editor.*

Eastern Province Agricultural and Trade Show.—In August, at Morogoro, Tanganyika. Organised by the Arusha Chamber of Commerce and Agriculture, P.O. Box 141, Arusha, Tanganyika.

***Training Student Engineers: Congrès International d'Etudiants Ingénieurs.**—Sun., 3 Aug., to Sat., 9 Aug., at Brussels. Organised by the Fédération Belge des Etudiants Ingénieurs (F.B.E.I.), Brussels. Apply to Mr. Leandro Alimenti, 9 Rue Camille Lemonnier, Brussels. (Additional information.)

Western Packaging and Materials Handling Exposition.—Mon., 11 Aug., to Wed., 13 Aug., at the Civic Auditorium, San Francisco. Organised by Clapp and Poliak Inc., 681 Market Street, San Francisco.

Mathematicians, International Congress of.—Thurs., 14 Aug., to Thurs., 21 Aug., in Edinburgh. Offices: 16 Chambers Street, Edinburgh 1.

Western Electronic Show and Convention.—Tues., 19 Aug., to Fri., 22 Aug., at the Pan Pacific Auditorium, Los Angeles. Organised by Wescon, 342 North La Brea Avenue, Los Angeles, Cal., U.S.A. Apply to Export Publicity and Fairs Branch, Board of Trade, Lacon House, Theobald's Road, London, W.C.1. Tel. CHAncery 4411.

***Scientific Instruments Exhibition.**—Tues., 19 Aug., to Fri., 22 Aug., at The University, Adelaide, South Australia. Apply to Mr. J. H. Lindsay, (South Australian Division of the Institute of Physics), 1 Hawke Street, Linden Park, South Australia.

Australian and New Zealand Association for the Advancement of Science, 33rd Congress.—Wed., 20 Aug., to Wed., 27 Aug., at Adelaide. Apply to Dr. R. S. Burdon, Department of Physics, University of Adelaide, Adelaide, South Australia.

"Model Engineer" Exhibition.—Wed., 20 Aug., to Sat., 30 Aug., at the New Horticultural Hall, Greycoat Street, London, S.W.1. Organised by The Model Engineer (Percival Marshall & Co., Ltd.), 19-20 Noel Street, London, W.1. Tel. GERrard 8811.

***Izmir International Trade Fair.**—Wed., 20 Aug., to Sat., 20 Sept., at Izmir, Turkey. Apply to the British Chamber of Commerce in Turkey, P.O. Box 190, Galata, Istanbul, Turkey.

Mathematical Statistics Conference.—Fri., 22 Aug., to Mon., 25 Aug., at The University, St. Andrews. Organised by the Royal Statistical Society, 21 Bentinck Street, London, W.1. Tel. WELbeck 7638.

***Rhodesian Agricultural Show.**—Wed., 27 Aug., to Sat., 30 Aug., at Salisbury. Organised by the Rhodesian Agricultural and Horticultural Society, Salisbury.

BRITISH ASSOCIATION

British Association Meeting.—Wed., 27 Aug., to Wed., 3 Sept., in Glasgow. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 4677.

British Radio and Television Exhibition, 25th.—Wed., 27 Aug., to Sat., 6 Sept., at Earl's Court, London, S.W.5. Organised by the Radio Industries Council, 59 Russell Square, London, W.C.1. Tel. MUSeum 6901.

Combustion, Seventh International Symposium on.—Thurs., 28 Aug., to Wed., 3 Sept., at Oxford University, and the Royal Institution, Albemarle Street, London, W.1. Organised by the Combustion Institute, 936A Union Trust Building, Pittsburg 19, Pa., U.S.A. Communications to The Combustion Institute Committee, c/o The Institute of Fuel, 18 Devonshire Street, London, W.1. Tel. LANgham 7124.

British Food Fair.—Thurs., 28 Aug., to Thurs., 11 Sept., at Olympia, London, W.14. Organised by the Food Manufacturers' Federation, Inc., 10 Mount Row, London, W.1. Tel. LEGation 2933.

Salinity Problems in Arid Zones, Symposium.—In September, at The University, Teheran, Iran. Organised jointly by UNESCO and the Iranian Government. Apply to the Natural Sciences Department, UNESCO, 19 Avenue Kléber, Paris 16e.

Peaceful Uses of Atomic Energy, Second International Conference.—Mon., 1 Sept., to Sat., 13 Sept., at Geneva, Secretariat: 1 Place du Lac, Geneva, Switzerland. Apply to the secretary, the executive committee, 1958 Geneva Conference, Atomic Energy Research Establishment, Harwell, Berks. See ENGINEERING, 16 August, 1957, page 218.

Pan American Federation of Engineering Societies, 5th Convention.—Tues., 2 Sept., to Sat., 6 Sept., at Montreal, Canada. Organised by the Engineers Joint Council, 29 West 39th Street, New York 18.

Cybernetics, Second International Conference on.—Wed., 3 Sept., to Wed., 10 Sept., at Namur. Organised by the International Association for Cybernetics, 13 Rue Basse-Marcelle, Namur, Belgium.

Cologne Fair (Household Goods and Hardware).—Fri., 5 Sept., to Mon., 8 Sept., in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

***Aslib Annual Conference.**—Fri., 5 Sept., to Mon., 8 Sept., at The University, Nottingham. Organised by Aslib, 3 Belgrave Square, London, S.W.1. Tel. BELgravia 5050.

American Chemical Society.—Sun., 7 Sept., to Fri., 12 Sept., at Chicago, Ill., U.S.A. Organised by the Society, 1155 Sixteenth Street, Washington 6, D.C., U.S.A.

***Aeronautical Sciences, First International Congress on.**—Mon., 8 Sept., to Sat., 13 Sept., in the Instituto Nacional de Prevision, Alfonso XI, Madrid. Further information from the Royal Aeronautical Society, 4 Hamilton Place, London, W.1. Tel. GROsvenor 3515.

***Ions of the Transition Elements, Discussion on.**—Tues., 9 Sept., to Thurs., 11 Sept., in Dublin. Organised by the Faraday Society, 6 Gray's Inn Square, London, W.C.1. Tel. CHAncery 8101.

QUALITY CONTROL

***European Organisation for Quality Control.**—Wed., 10 Sept., to Fri., 12 Sept., in Essen, Western Germany. Theme: "Consumer-Vendor Relations." Organisation's offices: Koninginnegracht 101, The Hague, Holland.

Coal Petrology, First International Meeting on.—Wed., 10 Sept., to Sat., 13 Sept., at Heerlen, Holland. Organised by the Committee on Coal Petrology, Geoligsch Bureau, Akerstraat 86-88, Heerlen, Holland.

International Scientific Film Association: 13th Congress.—Wed., 10 Sept., to Sat., 20 Sept., in Moscow. Apply to the Scientific Film Association, 164 Shaftesbury Avenue, London, W.C.2. Tel. TEMple Bar 4694.

Shipping and Commercial Fishing Exhibition—Thurs., 11 Sept., to Wed., 17 Sept., in Hull. Organised by Anglo-European Exhibitions Ltd., 45 Park Lane, London, W.1.

Conservation of Nature and Natural Resources International Union for.—Thurs., 11 Sept., to Fri., 19 Sept., at Athens and Delphi, Greece. Sixth general assembly and seventh technical meeting. Union address: 31 Rue Vautier, Brussels, Belgium.

***Swiss National Autumn Fair (Swiss Comptoir).**—Sat., 13 Sept., to Sun., 28 Sept., in Lausanne. Fair offices; Palais de Beaulieu, Lausanne, Switzerland.

Kekulé Symposium on Theoretical Organic Chemistry.—Mon., 15 Sept., to Wed., 17 Sept., in London. Arranged by the Chemical Society under the auspices of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry. Offices of the Society: Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Large Dams, International Commission on, World Power Conference.—Mon., 15 Sept., to Sat., 20 Sept., in New York. Communications to the secretary, British National Committee on Large Dams, 201-202 Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 3966.

PUBLIC LIGHTING

***Association of Public Lighting Engineers, Annual Conference.**—Tues., 16 Sept., to Fri., 19 Sept., at the Royal Hall, Harrogate. Includes an exhibition of street-lighting equipment and an outdoor display of lamp columns and mobile equipment. Organised by the Association of Public Lighting Engineers, 76 Victoria Street, London, S.W.1. Tel. VICtoria 3655.

***American Institute of Chemical Engineers, National Meeting.**—Sun., 21 Sept., to Wed., 24 Sept., in Salt Lake City. Apply to the Institute's Greater Salt Lake City Section, P.O. Box 1889, Salt Lake City, Utah, U.S.A.

Gas Congress, Seventh International.—Mon., 22 Sept., to Thurs., 25 Sept., in Rome. Organised by the International Gas Union, 4 Avenue Palmerston, Brussels 4, Belgium.

Institute of Metals Autumn Meeting.—Mon., 22 Sept., to Sat., 27 Sept., in Birmingham. Offices of the Institute: 17 Belgrave Square, Westminster, London, S.W.1. Tel. BELgravia 3291.

Future of Non-Ferrous Mining in Great Britain and Ireland, Symposium.—Tues. and Wed., 23 and 24 Sept., at 21 Tothill Street, London, S.W.1. Organised by the Institution of Mining and Metallurgy, 44 Portland Place, London, W.1. Tel. LANgham 3802.

Gearing, International Conference.—Tues., 23 Sept., to Thurs., 25 Sept., in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, 11 July, p. 36.

"Photokina" International Photographic and Cinematographic Exhibition.—Sat., 27 Sept., to Sun., 5 Oct., in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Civil Engineering in Agriculture, Fifth Congress.—Mon., 29 Sept., to Sat., 4 Oct., in Brussels. Apply to the Agricultural Attaché, Belgian Embassy, 105 Eaton Square, London, S.W.1.

***European Management Conference.**—Tues., 30 Sept., to Fri., 3 Oct., in the Kongresshalle, Berlin. Apply to the British Institute of Management, 80 Fetter Lane, London, E.C.4. Tel. HOLborn 3456.

Chemical Engineering Exhibition ("KJEMI-TEKNIKK 58").—In October at Oslo. Organised by the Studieselskapet for Norsk Industri, Forskningsveien 1, Blindern/Oslo, Norway.

Recent Developments in Precast Concrete, Symposium.—Tues., 7 Oct., at the Building Centre, 26 Store Street, London, W.C.1. Apply to Concrete Ltd., 16 Northumberland Avenue, London, W.C.2. Tel. WHItehall 5504.

***Pre-Packing of Fresh Fruit and Vegetables, International Exhibition of.**—Tues., 7 Oct., to Thurs., 9 Oct., at the Royal Horticultural Society's new hall, Greycoat Street, London, S.W.1. Organised by the Produce Pre-Packaging Development Association, Agriculture House, Knightsbridge, London, S.W.1. Tel. BELgravia 6431.

***Radio Engineers' Canadian Convention and Exposition.**—Wed., 8 Oct., to Fri., 10 Oct., in the Exhibition Park, Toronto. Organised by the Institute of Radio Engineers, 1819 Yonge Street, Toronto 7, Canada.

***Office Equipment Exhibition.**—Fri., 10 Oct., to Sun., 19 Oct., in Paris. Exhibition offices: 6 Place de Valois, Paris 1er.

***Continuous Conveying Equipment, Discussion Meetings on.**—Tues. and Wed., 14 and 15 Oct., in Ostend. Held under the auspices of Section II of the Fédération Européenne de la Manutention. Apply to the British National Committee, 94-98 Petty France, London, S.W.1. Tel. ABBey 4761.

REINFORCED PLASTICS

***Reinforced Plastics Technical Conference.**—Tues., 21 Oct., to Fri., 24 Oct., at the Hotel Metropole, Brighton. Organised by the British Plastics Federation, 47-48 Piccadilly, London, W.1. Tel. REGent 2041.

***Dairy Show, 72nd Annual.**—Tues., 21 Oct., to Fri., 24 Oct., at Olympia, London, W.14. Organised by the British Dairy Farmers' Association, 17 Devonshire Street, London, W.1. Tel. LANgham 6903.

International Road Federation. Third World Meeting.—Sun., 26 Oct., to Fri., 31 Oct., in Mexico City. Offices of the Federation: Abbey House, Victoria Street, London, S.W.1. Tel. ABBey 6177.

Automatic Merchandising Convention and Exhibition, National.—Sun., 2 Nov., to Wed., 5 Nov., at Kiel Auditorium, St. Louis. Offices: 7 S. Dearborn Street, Chicago, Ill., U.S.A.

Scientific Instrument Manufacturers' Association of Great Britain (SIMA), Convention.—Thurs., 6 Nov., to Sun., 9 Nov., at the Majestic Hotel, Harrogate. Association's offices: 20 Queen Anne Street, London, W.1. Tel. LANgham 4251.

Cycle and Motor Cycle Show.—Sat., 15 Nov., to Sat., 22 Nov., at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Industries Association, Ltd., The Towers, Warwick Road, Coventry. Tel. Coventry 62511.

Electronic Computer Exhibition: Associated Scientific Symposium.—Mon., 24 Nov., to Thurs., 27 Nov., at Teddington. Organised by the National Physical Laboratory, Teddington, Middlesex. Tel. Molesey 1380.

***British Institute of Management, 1958 National Conference.**—Wed., 26 Nov., to Fri., 28 Nov., in Brighton. Theme: "The Challenge of Change." Institute offices: 80 Fetter Lane, London, E.C.4. Tel. HOLborn 3456.

Electronic Computer Symposium and Exhibition.—Fri., 28 Nov., to Thurs., 4 Dec., at Olympia, London, W.14. Apply to Radio Communication and Electronic Engineering Association, 11 Green Street, London, W.1. Tel. MAYfair 7874.

National Power Show (Exposition of Power and Mechanical Engineering).—Mon., 1 Dec., to Fri., 5 Dec., in the New York Coliseum, New York. Organised by the International Exposition Co., 480 Lexington Avenue, New York 17.

Smithfield Show and Agricultural Machinery Exhibition.—Mon., 8 Dec., to Fri., 12 Dec., at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Grea Western Boat Show.**—Fri., 9 Jan., to Mon., 19 Jan., 1959, at the Great Western Exhibit Building, Los Angeles. Apply to Show Management, 142 South Fairfax, Los Angeles, Calif., U.S.A.

Reliability and Quality Control in Electronics, Fifth National Symposium.—Mon., 12 Jan., to Wed., 14 Jan., 1959, at the Bellevue-Stratford Hotel, Philadelphia, Pa., U.S.A. Apply to Mr. R. Brewer, Research Laboratories, General Electric Co., Ltd., Wembley, Middlesex. Tel. Arnold 1262.

***Heating and Air Conditioning Exposition, 14th International.**—Mon., 26 Jan., to Thurs., 29 Jan., 1959, at the Convention Hall, Philadelphia. Organised by the International Exposition Co., Inc., 480 Lexington Avenue, New York 17, U.S.A.

***Canada Farm and Industrial Equipment Trade Show.**—Wed., 28 Jan., to Sat., 31 Jan., 1959, at the Coliseum, Exhibition Park, Toronto. Offices: 40 Wellesley Street East, Toronto 5, Ontario, Canada.

***Montreal National Salon of Agriculture, Seventh.**—In February, 1959, at the Show Mart, Montreal. Offices: 152 Notre Dame Street East, Montreal, Canada.

***Miami International Boat Show, 18th Annual.**—Fri., 20 Feb., to Wed., 25 Feb., 1959, at Miami. Offices: 615 S.W. Second Avenue, Miami 36, Florida, U.S.A.

***Chesapeake Bay Boat Show, Fifth Annual.**—Fri., 6 Mar., to Wed., 11 Mar., 1959, at the Fifth Regiment Armoury, Baltimore. Offices: 1006 Cathedral Street, Baltimore 1, Maryland, U.S.A.

***Electrical Engineers' Exhibition, Eighth.**—Tues., 17 Mar., to Sat., 21 Mar., 1959, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (Tel. LANgham 5927); and organised by the Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum Street, London, W.C.1. Tel. MUSeum 3450.

World Fishing Boat Congress, Second.—Sun., 5 April, to Fri., 10 April, 1959, at the headquarters of the Food and Agriculture Organisation of the United Nations (FAO), Rome. Apply to that organisation.

***Atom Fair and Nuclear Congress.**—Mon., 6 April, to Fri., 10 April, 1959, in the Public Auditorium, Cleveland. Organised by the International Atomic Exposition Inc., 117 South 17th Street, Philadelphia 3, Pa., U.S.A.

Co-ordination Chemistry, International Conference on.—Mon., 6 April, to Sat., 11 April, 1959, in London. Sponsored by the International Union of Pure and Applied Chemistry. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Engineering Exhibition (22nd Engineering, Marine, Welding and Nuclear Engineering Exhibition).—Thurs., 16 April, to Thurs., 30 April, 1959, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. Tel. WHItehall 0568.

National Industrial Production Show of Canada.—Mon., 4 May, to Fri., 8 May, 1959, in the Exhibition Park, Toronto. Sponsored by the Canadian Welding Society, the Canadian Council of Foremen's Clubs, and the American Society of Mechanical Engineers (Ontario Section). *Managers:* E. M. Wilcox Ltd., 19 Melinda Street, Toronto, Canada.

National Education and Careers Exhibition.—Mon., 25 May, to Thurs., 4 June, 1959, at Olympia, London, W.14. Organised by the National Union of Teachers. Exhibition offices: Hamilton House, Mabledon Place, London, W.C.1. Tel. EUSton 2442.

National Business Efficiency Exhibition.—Tues., 26 May, to Thurs., 4 June, 1959, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate Hill, London, E.C.4. Tel. CENtral 7771.

BRITISH TRADE FAIR

***British Trade Fair in Lisbon.**—Fri., 29 May, to Sun., 14 June, 1959. Organised by the Federation of British Industries, 21 Tothill Street, London, S.W.1. Tel. WHItehall 6711

***Oregon Centennial Exposition, Portland.**—Wed., 10 June, to Thurs., 17 Sept., 1959. **International Trade Fair.**—Wed., 10 June, to Wed., 24 June. At the Pacific International Livestock Pavilion, Portland, Oregon. Organised by the Oregon Centennial Commission, 400 Jackson Tower, Portland, Oregon, U.S.A. U.K. inquiries to Export Publicity and Fairs Branch, Board of Trade, Theobalds Road, London, W.C.1. Tel. CHAncery 4411.

***Information Processing, International Conference on.**—Mon., 15 June, to Sat., 20 June, 1959, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. An **International Exhibition of Data Processing Equipment** will be held in Paris at the same time. Inquiries in U.K. should be addressed to the honorary secretary, Group B, British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, London, W.C.2 (Tel. TEMple Bar 7676); and other inquiries to the Information Processing Department, Department of Natural Sciences, UNESCO Secretariat, Paris.

***Underground Machinery Manufacturers Council, Exhibition.**—Thurs., 9 July, to Sat., 18 July, 1959, at Olympia, London, W.14. Sponsored by the Council of Underground Machinery Manufacturers, c/o Peat, Marwick, Mitchell and Co. (P.O. Box 121), 301 Glossop Road, Sheffield 10. Organised by the Municipal Agency, 70 Victoria Street, London, S.W.1. Tel. VICtoria 9132.

***Fluorine Chemistry, Symposium on.**—Wed., 15 July, to Fri., 17 July, 1959, at The University, Birmingham. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

***Brisbane Agricultural and Industrial Exhibition.**—Fri., 7 Aug., to Sun., 16 Aug., 1959, in Brisbane. Organised by the Royal National Agricultural and Industrial Association, 99 Creek Street, Brisbane, Queensland.

***Perth Royal Agricultural Show.**—Sat., 26 Sept., to Fri., 2 Oct., 1959, in Perth. Organised by the Royal Agricultural Society, 9 Howard Street, Perth, Western Australia.

***International Clean Air Conference and Exhibition.**—Tues., 20 Oct., to Fri., 23 Oct., 1959, in Seymour Hall, London. Organised, in celebration of its diamond jubilee, by the National Society for Clean Air, Palace Chambers, Bridge Street, London, S.W.1. Tel. TRAfalgar 6838.

Production

MECHANISED DEPOT FOR DOMESTIC COAL

Advantage Taken of Railway Hopper Wagons

A mechanised coal depot to speed deliveries to domestic consumers has been built in North London. Possibly the first of its kind in the country, it belongs to Charrington, Gardner, Locket and Company Limited, and it was designed and engineered by Charrold, Charrington's engineering subsidiary. To be successful, such a plant must handle the coal carefully to avoid breakages, maintain a uniform rate of flow irrespective of size variation, and bag it with as little damage as possible. The new depot has been planned with the co-operation of British Railways (Eastern Region) and the National Coal Board.

Filled wagons arrive at the depot at the rate of three trains a week, each of eighteen 21 ton hopper bottomed wagons. There are three sidings at the depot, two of 600 ft length and one of 450 ft. The wagons are worked as a train, not only to reduce shunting and consequent degradation, but also to allow train load working and to receive the benefits of through routing and fast train loads of braked wagons. On arrival trains are divided into two sections and shunted on to the sidings. This enables one engine to deliver the filled wagons to the siding and to collect a load of empties for return to the pits, a system which considerably improves wagon utilisation.

Once the wagons have been delivered to the siding all movement is taken over by the siding staff. A powered winch supplied by A.C.E. Machinery Limited, is available for moving either half of the train, and any wagon can be positioned exactly as required. The wagons used are all of the standard 21 ton hopper type, and as these wagons are self emptying, the coal can be discharged from them without manual effort. The coal discharged from the wagon is received in a small hopper located beneath the rails, especially designed for the purpose. Once the initial fall of coal from the wagon has occurred a column of coal is formed between the hopper and the wagon and discharge cannot continue until coal is taken from the hopper. A Carlton Engineering reciprocating feeder transfers the coal to the main conveyor and so regulates the rate of fall from the wagon. Water sprays at rail level control the spread of dust.

The Wharton elevating conveyor is of the articulated steel-pan type with a horizontal section extending under the three sidings. It then rises at an angle of 30° to raise the coal to the bunkers. It is 127 ft long and can handle 120 tons of coal per hour. The vertical lift is 50 ft from bottom of the pit to the top of the conveyor. At the discharge end of the conveyor the coal passes over a Niagara screening unit where any small, made in transit, can be removed and collected in two hoppers. These are arranged to discharge directly to bulk vehicles. The screen is a double-decked vibrating type, equipped to remove any coal below $\frac{5}{16}$ in but the sizing can be changed as required.

From the screen unit the coal is transferred to a Niagara shuttle conveyor for distribution to any one of a bank of twelve hoppers. This conveyor is 36 in wide of 4 ply 32 oz duck rubber and canvas, and 70 ft long. It is reversible and has a control cabin at each end. The operator also controls the reciprocating feeder and the main conveyor. All are arranged for sequence operation to avoid pile up at any point.

In order to avoid breakage of the coal, the hoppers are fitted with rubber-lined guides which operate in conjunction with a dividing arm on the shutter conveyor to prevent a long drop of the coal when the hopper is empty. The capacity of each hopper is approximately 20 tons, and they all terminate in Charrold bagging feeders. The discharge height is 11 ft from the ground, with a bag scale platform 7 ft from the ground and a loading platform 3 ft 6 in from the ground. The design is intended for the lorry crew to move the sacks to the lorry on their backs.

Coal is brought forward on a belt by pressure on a foot switch and falls into the sack which stands on the scales. The fine control obtained over the rate of flow and the clear view of the coal coming forward simplify weighing. Each unit has a capacity of 10 tons an hour.

To provide a ballast stock to cover fluctuations in supply and demand, storage bays are provided on the site. The walls of these bays are formed from Stelcon free-standing units and capacity is provided for 6,000 tons. When coal is to be put into stock, the shuttle conveyor is traversed beyond the end of the hopper bank and coal discharged on to a long chute. The chute conveys the coal down to ground level from where it can be picked up by a Muir Hill mobile shovel and transported to the appropriate storage place. In order to make full use of the space available, a Fyson's mobile conveyor elevates the coal if required. When stock is recovered coal is picked up from the ground with the mobile shovel and put back into the wagon discharge hoppers.

One of the features of the plant is the simplicity of operation. Only two men are required for the unloading: the operator who sits in the control cabin of the shuttle conveyor and starts the conveyor system, and a shunter who positions the wagons over the hoppers and watches the actual discharge. Bagging is normally carried out by the lorry crews and then there is the mobile shovel driver to feed the stock piles. Thus three men handle over 1,100 tons of coal each week, a feat largely made possible by the use of the hopper wagons. Amenities have not been forgotten and in the gate house, where is the control room for the weighbridge, there are also showers and changing rooms. The plant handles all grades of domestic coal as well as coke and anthracite.

Fig. 1 Coal discharged from railway hopper wagons is elevated to bunkers by an articulated steel-pan conveyor at the new mechanised depot built to distribute coal to domestic users in north London.

Fig. 2 The twelve bunkers feed bagging units arranged for manhandling the sacks on to lorries.

Fig. 3 A foot switch controls the flow of coal into the sack.

MECHANICAL HANDLING IN IRON PRODUCTION: *Film*

The Mechanical Handling Engineers' Association have sponsored a 16 mm colour film, with sound commentary, on " Mechanical Handling in Iron Production." Produced by John Byrd, the film, which runs about 35 min, covers the handling of materials used in iron manufacture from the winning of home-produced ore, and the reception of imported ore, through its transport by rail to the mill, and the final processing in the blast furnaces, to the tapping of the molten slag and iron. The film is available on loan from the offices of the Association, 94/98 Petty France, London, S.W.1.

Construction

SCRUBBERS AND PIPELINES OF TIMBER

Santa Fe Equipment Available in U K

Since 1903 the Santa Fe Tank and Tower Company of California have been supplying American industry with wooden scrubbers and pipes. Head Wrightson Processes Limited, London, through the Santa Fe Division of their American associates, The Fluor Products Company, are now able to offer in the United Kingdom, British Commonwealth and Europe, this type of timber equipment. This is a logical development from the many years of experience gained by the company's activities in engineering and supplying the timber "Counterflo" cooling towers incorporating a novel timber-pipe distribution system for the cooling water.

Cylindrical scrubbers are used in many industries to separate solid or liquid impurities from gas. The "Santa Fe" cylindrical scrubber has proved to be mechanically superior to the rectangular design. It is self-bracing, thus avoiding a costly system of posts and supporting framework, and requires fewer bolts, fastenings and other metal parts which are exposed to corrosive gases. The design also provides a smooth internal surface free from "dead air" pockets, for the control of air turbulence, and ensures a more efficient gas recovery system.

These scrubbers are of wood stave construction and can be adapted to meet particular industrial requirements. The minimum of external hardware can be furnished in hot-lead dipped steel, Monel, stainless steel, brass and bronze. The spray systems are available in various materials. When internal air straighteners or drift eliminators are required, they can be made of wood which is not subject to corrosion.

The advantages of wood as a material for pipelines is that, being a poor conductor of heat, the possibility of a freeze-up at low temperatures is reduced, while its flexibility prevents bursting and permits curvatures in installation without the necessity for special fittings. Since the amount of thermal movement due to temperature changes is small, there is no need for expensive expansion joints. Furthermore, flowing water in wood pipes remains cool, even when pipes are laid on the surface in warm climates, so that it is not essential to bury these pipes. In rough country the cost of wood-pipe construction is frequently less than the provision of open canals; in addition, the water can be conveyed under pressure and the flow is not interrupted by the formation of ice. Water conveyed by pipelines is also free from the troublesome growths often found in open canals.

Wood pipe has many other applications besides municipal water systems. It is extensively used in mines, manufacturing plants, irrigation systems, reclamation projects, and hydro-electric plants. In industrial operations the uses may range from conveying chemical solutions to transporting factory wastes.

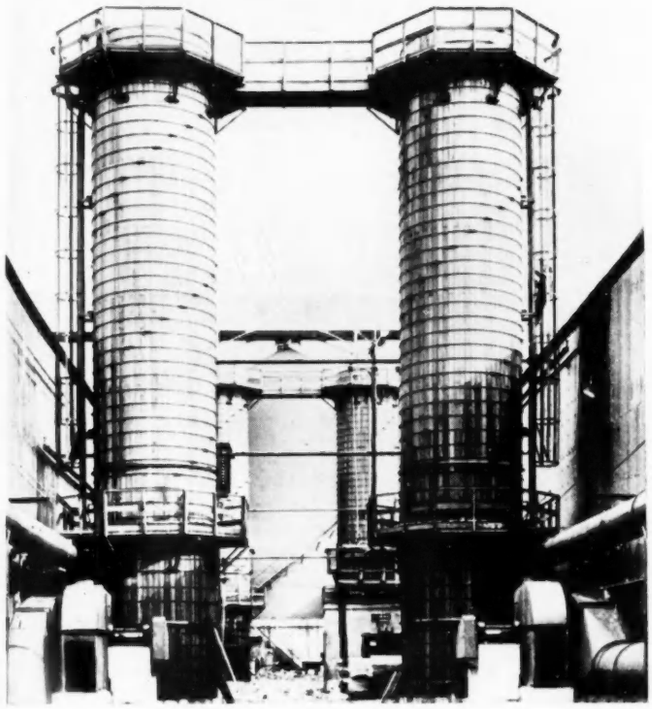


Fig. 1 (left) Group of cylindrical gas washers of timber construction.

Fig. 2 (below) Timber pipeline for hydro-electric plant, 12 ft internal diameter.

ECONOMICS OF PRE-CAST PRESTRESSED BRIDGE CONSTRUCTION

Despite all its publicised advantages pre-cast prestressed concrete, for bridges at least, has frequently proved to be more expensive than *in situ* concrete. Lack of experienced workmen and the use of too-involved site operations are given as the main reasons for such higher costs in a paper by Mr. K. M. Wood, chairman and joint managing director of Concrete Limited, Northumberland Avenue, London, S.W.1.

Based on the experience of his own firm Mr. Wood contends that the time required to handle prestressing wires and prestressing equipment could be reduced to one-third or less—a reduction of 66 per cent—if the operators were given proper training and the opportunity of becoming experienced at their work. Such a saving would almost invariably cut the cost of pre-cast prestressed work below that of site concrete. Many of the site operations which are undertaken to-day are described as being too difficult for sound construction work to be produced by typical site personnel, though such operations may be perfectly feasible under factory or laboratory conditions.

In an attempt to resolve these and related problems—choice of equipment and working procedure, the effect of standardisation—Concrete Limited are making an extensive study of possible methods of construction in prestressed concrete. As part of this study full-scale sections of bridge decks are being built and recently the firm's Hounslow works, where the tests are being conducted, were open for inspection.

In addition to the effort to determine adequate site methods, the tests provided an opportunity to establish target times for estimating and cost control. The principal operations being studied were the erection of pre-cast members; the fixing of shuttering for the site placing of a concrete bridge deck and the formation of diaphragms; cross-stressing or reinforcing (of which a few failures have been reported recently); and the production of post-tensioned beams, both cast in one unit and in sections, and grouting. As an addition to the above programme a test is being planned on the load distribution across a bridge deck built from hollow pre-cast members with different amounts of cross-stressing. It is hoped that this test will establish that satisfactory distribution characteristics can be obtained in this form of decking with comparatively small amounts of cross-tensioning, if correctly positioned.

The tests outlined are under the direct control of Dr. F. W. Gifford, M.I.Struct.E., A.M.I.C.E., the chief engineer of the company. Emphasis is being laid on bridges of spans up to 75 ft and, to a lesser extent, on bridges in the range of 75 to 125 ft span. For the former, not exceeding 75 ft span, it is usually most economical to pre-tension, using standard steel shutters; for the longer spans it is more economical to erect post-tensioned girders. Above spans of 125 ft the type of construction has to be considered in relation to the particular site.

Continuing **Construction**

LINES ACROSS MARSHES

Super Grid Extensions

A further 11·5 miles of the 275 kV grid, between Tilbury and Rayleigh in Essex, has been erected by the Contract Department of W. T. Henley's Telegraph Works Company Limited, 51-53 Hatton Garden, London, E.C.1. It is of standard double-circuit construction, with twin 0·4 sq. in copper-equivalent steel-cored aluminium conductors for each phase. The line crosses country parallel to the Thames estuary and runs over marshy ground for about 6 miles of the route. Because of the bad bearing

A linesman about to climb into the spacer-fitting chair.

properties of the ground over these stretches, massive piled tower foundations were required. Some of the piles driven at tower footing positions exceed 90 ft; the average depth is about 50 ft. Reinforced mass concrete foundations were cast for the footings and connected with reinforced concrete tie beams. All the piling was carried out by West's Piling and Construction Company Limited, using shell piles. Truck mixed concrete was used throughout the work; on sites inaccessible to dumpers, narrow railway track was laid.

Near the centre of the route, where Vange Creek is crossed, the towers reach a height of 216 ft. They are normal towers with 80 ft extensions, the height being necessary because sailing barges use the creek. During stringing operations, tubular scaffoldings formed of "unit frames" were used to clear conductors over roads so as to enable traffic to pass uninterrupted. Following normal twin-conductor practice, spacers were fitted at intervals between the two conductors comprising each phase, and sag-adjuster plates, incorporated in the tension insulator set arrangements, enabled the twin conductors to be accurately aligned.

Engineering at Home

COLD PLUMBING

An emergency repair kit is the latest in a range of Devcon products marketed by E. P. Barrus (Concessionaires) Limited, 12-16 Brunel Road, Acton, London, W.3. Devcon is referred to by its makers as plastic steel, and the new kit is intended for permanent repairs to pumps, valves, pipes, tanks, etc. It is stated to be possible to carry out a repair while the damaged unit is under pressure.

The emergency kit consists of a 1 lb can of Devcon, a hardening agent, a piece of rubber-lined steel, a release agent (for use where it is undesirable for the steel to "marry" with another surface), a supply of treated laminated glass tape, and directions for use. The glass tape is an innovation. It is used where high strength is required or where large or corroded holes are present. The Devcon is spread on the tape, which is then applied as a bandage to the leak or hole. The tape, however, is not always essential; for example, in laboratory tests, a series of $\frac{5}{16}$ in holes were filled with Devcon and subsequently withstood an internal pressure of over 2,000 lb per sq. in. The marketing company claim that Devcon, used with the laminations of the glass tape, has a compression strength of over 50,000 lb per sq. in and a tensile strength of over 45,000 lb per sq. in.

Devcon A and Devcon B each contain approximately 80 per cent steel and 20 per cent plastics. Two hours after the addition of the special hardening agent the material becomes a rigid metallic piece. It is essentially non-shrinking or expanding. A mass of 1,000 cu. in will harden completely in 2 hours. It will set under water and does not depend on evaporation for hardening. Apart from the emergency application mentioned, it can be used as modelling clay, and can be applied to vertical surfaces. It adheres to iron, steel, bronze, brass, aluminium, lead, porcelain, glass, wood, and concrete. Devcon can also be used for bonding these materials together.

Devcon C is a heat-resistant material which can be used for making plastics and rubber moulds and for similar applications requiring strength at elevated temperatures. Devcon F (aluminium putty) is for filling large holes in aluminium castings, for building up worn metal parts, and for making models. Devcon WR is a hard, tough material that will, its makers claim, outwear steel. Devcon Flex, which makes the previously mentioned varieties flexible, can be used instead of the regular hardening agent to give greater impact resistance and increased adhesion.

LOOKING AT EUROPEAN HOUSING

The financing of housing in Europe, its policy and trends, building costs, urban development and town planning, and the use of space in dwellings were among the questions considered by the United Nations Economic Commission for Europe's Housing Committee at a session held in Geneva during June. Over 20 countries took part as well as representatives of specialised agencies and international organisations. Among the items on the agenda were standardisation and modular co-ordination. The committee decided to hold an *ad hoc* meeting to study this particular question and suggested June, 1959, as a suitable date. The meeting would be concerned with the practical application of standardisation and modular co-ordination, within the framework of government policies, by the building professions and industries, including producers of building materials and components. One of the main objectives of the meeting would be to promote international trade.

It was also decided that attention would be paid to the trend of productivity in the building industry and means of increasing it, as well as to the use of plastics, lightweight concrete, light metals, and lighter forms of steel.

The committee noted with appreciation a provisional report based on information supplied by ECE members, covering the problem of financing housing as a whole. The report, to be published this year, comprises five chapters, the final one being concerned almost entirely with problems and policy issues facing public authorities. Several representatives suggested that a separate inquiry should be made into the housing-mortgage market and the future role of the private providers of rented accommodation. The committee also examined a provisional report on the formulation of house-building programmes in the various European countries.

UP-ENDING RADIATORS

It is not always possible to use long horizontal panel radiators, because of lack of wall space. In such situations vertical mounting can provide a solution. The adjacent illustration shows a 9 ft panel—manufactured by Gulf Radiators Limited, 229 Regent Street, London, W.1.

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